AGRICULTURE AND WATER USE: PRESENT AND FUTURE ISSUES

HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

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CONTENTS

WITNESSES

	Page
October 25, 1983:	
Barbara J. Lausche, project director, food and renewable resources program, Office of Technology Assessment; and Dr. Clifford J. Murino, president, University Corporation for Atmospheric Research	1
Bruce H. Smith, district fisheries biologist, Rock Springs, Wyo. district office, Bureau of Land Management; accompanied by David Tidwell, Special Assistant to the Director, Bureau of Land Management; and Dr. Robert Locy, Native Plants, Inc., Salt Lake City, Utah	33
Appendix: Questions and answers submitted for the record	55

AGRICULTURE AND WATER USE: PRESENT AND FUTURE ISSUES

TUESDAY, OCTOBER 25, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH, AND ENVIRONMENT,
Washington, D.C.

The subcommittee met, pursuant to call, at 1:42 p.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Present: Representative Schneider.

Mr. SCHEUER. The Subcommittee on Natural Resources, Agriculture Research, and Environment will come to order. The hearing will commence.

I apologize for the delay. We had a flurry of rollcall votes a few minutes ago. I have been waiting for some of my colleagues to show up, and I am sure they will. But in the meantime we will push ahead with our hearing.

The first panel will be composed of Barbara Lausche, who is project director of this water-related technologies study for sustainable agriculture in U.S. arid/semiarid lands, and Dr. Clifford Murino of the University Corporation for Atmospheric Research, otherwise known as UCAR, and he is on the advisory panel of this study. So will Dr. Murino and Barbara Lausche come to the witness table.

All right. We're very happy to have both of you. We apologize for the delay again. Why don't each of you speak informally for 8 or 10 minutes and then I'm sure we'll have some questions for you. So, Miss Lausche, why don't you start out.

STATEMENTS OF BARBARA J. LAUSCHE, PROJECT DIRECTOR, FOOD AND RENEWABLE RESOURCES PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT; AND DR. CLIFFORD J. MURINO, PRESIDENT, UNIVERSITY CORP. FOR ATMOSPHERIC RESEARCH

Ms. LAUSCHE. Thank you.

Mr. Chairman, I appreciate the opportunity to be here this afternoon, and I would like to offer very briefly, in summary form, some of the findings of an OTA report that has just been released earlier this month. The title of that report is "Water-Related Technologies for Sustainable Agriculture in U.S. Arid/Semiarid Lands." This is the full report. As is typical of OTA studies, we have had a separate release, separate publication, just of the summary chapter

itself, and then a separate one-page brief. Copies of these publications are on the table in the back. Also as part of this study we produced a background paper with five foreign experiences which we relate to this topic.

I would like to summarize some of the findings of this study and then conclude with some of the national policy issues identified in that study which Congress might address to help insure long-term agricultural productivity.

I am the project director, as you mentioned, of that study. The OTA process in this case started with a request from the House Agriculture Committee to look at the possible water-related technologies for sustaining agriculture in arid/semiarid lands. It involved more than 100 technical experts in this process, which has been going on for about 2½ years.

The study itself focused on wide ranging technologies, and a number of folks here today will talk about those a little more specifically. I would like to divide my discussion into three broad areas: first, the water-related problems for western agriculture as we identified them in the study; second, some of the institutional and technological issues for sustainable agriculture in the West; and third, a few of the options which are appropriate for discussion here today.

Quickly, to summarize the problems that we identified in the assessment with respect to western agriculture, we focused on three of the most serious problems; that is, the availability of renewable water supplies in the West, the water quality deterioration in the West, and salt build-up in soils.

The OTA study found that available estimates of water supply and use indicate that almost half of the Western United States is currently experiencing water supply problems in relation to demand, and in the testimony that I'll submit, I have included a figure showing the Western States, areas that are experiencing water supply demand problems, and also a table which defines in this a little bit more detail.

Ground water problems are increasing in the West as a major aspect of western water supply problems. In much of the Southwest and southern high plains, for example, ground water is being withdrawn faster than it's being replaced. This, while it is a localized problem, has potentially significant effects, such as the loss of one's productive farmland, higher pumping costs, and land subsidence. To give you a couple of examples, parts of the lower Colorado River Basin, including some of the critical use areas of Arizona, are experiencing declines in the water table from 4 to 10 feet per year. Land subsidence has had serious economic consequences for such areas as California's San Joaquin Valley, where as of 1967 ground water withdrawals had produced subsidence of up to 20 feet over the prior 40-year period, and this was for an area of approximately 2,500 square miles. San Jacinto Valley in California is another example where we've got approximately 5,200 square miles with subsidence at a rate of 1.2 feet per year since measurements began in 1935. In some portions of that valley subsidence has reached a total of 28 feet.

Now, water supply demands are increasing in the West. Pressures are increasing to shift water to new uses and, as a result of

these forces, the study found that predictions that water will increase in cost in the West are very likely.

Moving on to water quality problems, the problems with respect to water quality deterioration in the West are not unique. We have water quality problems as well in the east, but the special characteristic of the western area is that we have less water for dilution. The volume of water in the west is smaller by at least a half than that in the more water-abundant eastern part of the country; thus, any given water use has a potential of causing increased water quality deterioration. And because of the interconnection between ground water and surface water, when you contaminate a ground water supply in the West, you're going to have potentially serious surface water problems as well in some areas.

Relatively little can be done technologically in a manner that is economically feasible to remove and contain a contaminant once it's in the ground water, so we are suggesting in this study that a very conservative approach to the use of ground water and areas that could eventually cause leaching of contaminants into ground water be pursued.

At the same time, ground water quality and surface water quality research is very site specific and incomplete, with few integrated analyses on a regional basis or on broad, cumulative impacts of different contaminants.

Soil salinity as a problem in the West is a special hazard because we have an estimated 25 to 35 percent of the irrigated cropland especially being affected by high levels of salinity, and the problem appears to be growing. In part, this is due to intensive land use with inadequate water supplies to flush the salts out of the plant root zone. Examples of severe, in some areas, soil salinity problems are California's Imperial Valley and parts of New Mexico.

Salinity values—salinity levels on irrigated land pose a major limitation to crop production because even though the soils may be wet, excessive salt concentrations can interfere with salt water uptake and reduce crop yields.

With these three problems in mind, I want to move now on to some of the institutional and technological issues that we identified.

First of all, a number of technologies were assessed in this study and there were a number identified with promising potential in various parts of the West. At the same time the study found a number of recurring institutional problems that affect the evaluation of a technology and its effectiveness at a particular site. These include our knowledge about the natural resources involved, the level of cooperation among Federal agencies who are manipulating resources affecting agriculture, and the extent of participation of affected producers and other water users in government decisionmaking.

I want to quickly go through these: The information base, cooperation among Federal agencies, and user participation. First of all, with respect to the information base, successful application of a particular technology is site specific and requires an understanding of the hydrologic cycle and other natural processes involved. Well, for us to have an understanding of this, we need information; we need data.

The OTA study found that at present the analysis of western hydrologic regimes and natural processes affecting agriculture is fragmented and incomplete. We've got examples where the mountain snow pack is a major water-producing area of the West; yet there is very little research done in that area. Similarly, rain-fed agricultural systems which may be increasingly relied upon in the future, because in some areas irrigation is going to receive increased pressure; we need more focus and stress in that area, particularly including stress resistant varieties of conventional crops and other crops that are not now domesticated or widely grown. Likewise, research and monitoring of agricultural and health impacts of contaminants in the water is needed both for national and local decisionmaking and, as yet, there is very little research in this area.

With respect to coordination, a number of agencies, as I'm sure you're aware, are involved with resource management as well as science and technology research affecting western agriculture. Yet there is no framework for coordination, and interaction is essentially on a problem-by-problem basis.

The OTA assessment found a substantial need—and there are a number of examples in the assessment really illustrating the need—to improve Federal agency coordination and to improve interaction of water-related agricultural activities within government agencies.

Third, with respect to user participation, the OTA study found that development and successful application of water-related technologies depends, in part, on the ability of the researcher and user to adapt them to local conditions. But at the same time there are often gaps in this interaction; and especially this was expressed on the part of some of our advisory panels who are farmers and are working and struggling and trying to maintain an economically productive farm unit in the West. The focus, the need for increased researcher-user interaction, is extremely important in the minds of these folks.

As well, increased participation and decisionmaking is needed for those communities and individuals, especially, for example, Indian water-right holders in the West, who may have important interests in water and in what decisions are made about water. This is important and will be increasingly so to insure lasting settlement of conflicts over use, to insure that decisions are solid and are actually enforced.

With these in mind, in the testimony here I have noted a few technologies that—just to give examples of the types of things that we focused on in the assessment. And while technologies themselves are not sufficient to address the problems, I wanted to relate a few of these, particularly since there are a number of opportunities where we can be doing more research and science and technology development.

First of all, specific applications of biology to the problems of plant and animal water use in arid/semiarid lands has significant potential.

Mr. SCHEUER. I can't hear you. You're talking a little bit fast.

Ms. LAUSCHE. OK. Thank you.

Mr. SCHEUER. Would you just repeat that last sentence?

Ms. LAUSCHE. OK. Significant applications of biology to the problems of plant and animal water use in arid and semiarid lands have substantial potential. Biological technologies such as tissue culture of rangeland, dry-land, and irrigated crops are in commercial use and analogous methods are used in animal breeding. The broader use of native organisms, the domestication of new crops, and new approaches to plant breeding have potential for tailoring agriculture more specifically to arid/semiarid lands.

At the same time, there are institutional hurdles to be covered. General disinterest from the established agricultural community and incomplete research adversely affect their development.

Second, improved water delivery systems that provide increased flexibility for on-farm irrigation are receiving increased attention. Existing facilities and management practices, especially regarding release of water from reservoirs, will require extensive modifications before benefits from this technology can be realized, however.

Third, opportunities exist for improving soil-water conditions, but effective use again requires an application of more than one technology and successful application is site-specific and difficult to quantify given the wide variability in site conditions across the region.

Fourth, improved water-supply forecasting is an important technology that could be one of the most significant advances related to precipitation and runoff in the Western United States for long-term sustainable agriculture because it directly links the timing and volume of water available for the downstream and lowland agricultural user.

And fifth, opportunities to develop large sources of previously unavailable surface water or to augment existing supplies through such means as construction of new storage facilities, desalinizaton, or interbasin transfers, the study found, were technically—technologically feasible, but are likely to have substantial problems in the future, in the near future at least, because of the difficulties in economic, environmental, legal and socioeconomic areas.

In contrast, while we still have work to do with verification criteria, weather modification does appear to be an economically attractive augmentation technology that has developed within a solid scientific framework to facilitate future advances.

Mr. SCHEUER. Weather modification?

Ms. LAUSCHE. Yes.

With these overview comments, I would like to summarize briefly with a couple of the options that the study identified as important from a national perspective to deal with and help create a sustainable western agriculture.

As I have briefly referred to previously, an important theme of the assessment has been the need for integration and, in fact, the need for a systems approach, both to science and technology and to institutional decisionmaking regarding policies and programs that affect agriculture and water-related technologies.

As noted above in the prior comments, however, a number of institutional inadequacies related to research, data analysis and synthesis, coordination, and user participation hinder this integrated approach.

30-599 O - 84 - 2

The study identified a number of efforts where the States have begun to take a more active role in resolving growing conflicts over water use and improving resource management for agriculture and other uses. At the same time, the assessment found that direct, and in some activities expanded, Federal involvement would be important, particularly regarding Federal water issues, topics of broad geographic and international character, equity concerns, and insuring that users are involved in decisionmaking, and then support for State efforts.

I would like to conclude now with some points highlighting some of the major options identified in the assessment for congressional action.

First, a need exists for a coherent and coordinated mechanism for the Nation's university research programs in water resources and water resources management for national, regional, and local problem solving and policymaking. Congress could establish—and the OTA study identified a number of points for establishing—a National Center for Water Resources Research to serve this function.

Second, improved information is needed by Congress to provide a basis for making decisions and setting goals affecting resource sustainability. Ongoing analysis and synthesis of existing data bases could provide improved information on the dynamics of the resource system and how interactions among resource components affect the sustainability of western agriculture as well as eastern agriculture. A technical unit—for example, some type of unit focused on resource analysis—could be established to provide Congress with ongoing quantitative evaluations of the state of the renewable natural resource system as a consequence of near- and long-term congressional policies and programs.

Third, sustaining the long-term productivity of the natural resource base upon which agriculture depends requires an improved understanding of the natural processes involved. Congress could support strengthened research in such areas as the water-producing properties of the mountain snowpack, rain-fed agricultural research, both for dryland and rangeland agriculture, to expand opportunities for long-term productivity on these lands, and comprehensive areawide water quality research and monitoring of agricultural and health effects of contaminants in water.

Fourth, water users in agriculture and other activities potentially affected by water-related decisions need increased participation in decisionmaking. Congress could increase opportunities for participation of Indian reserved water-right holders in both Houses of Congress and could consider establishing a select committee to investigate and recommend legislation to protect the renewable natural resource interests, including water, of disadvantaged populations. In addition, Congress could provide mechanisms, through such means as advisory bodies, to increase agricultural user/research interaction regarding the relevance and practicality of technology research and development for agriculture.

With these brief comments, which not at all have gone into the depth of the report, I would like to close and am willing to answer any questions.

Thank you.

[The prepared statement of Barbara Lausche follows:]

TESTIMONY OF BARBARA J. LAUSCHE

PROJECT DIRECTOR, FOOD AND RENEWABLE RESOURCES PROGRAM

OFFICE OF TECHNOLOGY ASSESSMENT

BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH

AND ENVIRONMENT OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

Water-Related Technologies for Sustainable Arid/Semiarid Agriculture

October 25, 1983

Mr. Chairman, thank you for your invitation to participate in this hearing. I would like to offer some relevant findings of an OTA report related to this topic released earlier this month, Water-Related Technologies for Sustainable Agriculture in U.S. Arid/Semiarid Lands, and conclude with a summary of some national policy issues identified in that study which Congress might address to help enhance long-term agricultural productivity. I am the Project Director for that OTA study.

The OTA assessment on water and arid/semiarid agriculture was requested by the U.S. House of Representatives, Committee on Agriculture. The assessment process involved the input of more than 100 technical experts in an advisory panel, workgroups, workshops, and as authors of background papers and reviewers of drafts. While its specific focus was the long-term impacts and potentials of water-related technologies for the seventeen western states (the generally U.S. arid/semiarid lands), many of the policy, institutional and resource management issues identified in the assessment have national implications and broad relevance for both the West and the more water-abundant Eastern United States.

The study examined technologies for 1) improving water-use efficiency for rain-fed agriculture (dryland or rangeland) and irrigation; 2) improving water-management, storage, and distribution; and 3) augmenting existing water

supplies. In addition, a background paper, Water-Related Technologies for Sustainable Agriculture in Arid/Semiarid Lands: Selected Foreign Experience, was published separately as part of the assessment.

The assessment identifies a number of technologies that show promise. Other witnesses this afternoon will discuss some of these technologies and one of the specific options identified by the study that Congress could consider to improve information and coordinate research on water resources. I will discuss OTA's broad findings under the following headings:

1) water-related problems for Western agriculture,
2) institutional and technological issues for sustainable Western agriculture, and
3) selected options for congressional consideration.

Water-Related Problems for Western Agriculture

The OTA assessment found that agriculture in the arid/semiarid United States is not only being increasingly threatened by water-related problems, but also that these problems are likely to intensify in the future. Western agriculture contributes a large share of the total income derived from farming and ranching in the United States--43 percent of the 1980 U.S. farm income. This means that Western agricultural problems are national problems. The most serious problems relate to availability of renewable water supplies (including the problems of ground water depletion), water quality deterioration, and salt buildup in soils.

Water supplies: Available estimates of water supply and use indicate that almost half of the Western United States is currently experiencing water-supply problems in relation to demand (figure 1 and table 1). Surface water shortages exist annually or seasonally in at least some portion of each of the

major water resource regions of the Western states. In almost all cases, these shortages are offset by water reuse and ground water pumping. In much of the Southwest and southern High Plains, ground water is being withdrawn faster than it is replaced (often called ground water "mining") in order to sustain present levels of use.

Ground water use in the Western United States almost tripled between 1950 and 1975, and the ground water percentage of the total water withdrawn in the western region nearly doubled. The perception that ground water is an inexhaustible resource has gradually changed during the last 30 years. One reason for this is that awareness is growing that some aquifers were filled over thousands and millions of years and may not be recharging at rates that can match current rates of withdrawal.

While ground water "mining" (withdrawal in excess of recharge) is a localized problem, it has potentially significant effects--loss of once productive farmland, higher pumping costs, and land subsidence--for those agricultural areas impacted. Parts of the lower Colorado River Basin, including some critical use areas of Arizona, are experiencing declines in the water table of from 4 to 10 ft/yr. Land subsidence has had serious economic consequences for such areas as California's San Joaquin Valley where as of 1967 ground water withdrawals had produced subsidence of up to 20 feet over the prior 40 year period for an area of 2,500 square miles. Approximately 5,400 square miles of cropland in California's San Jacinto Valley have subsided at a rate of up to 1.2 ft/year since measurements began in 1935. In some portions of that Valley subsidence has reached a total of 28 ft.

Water-use demands for existing supplies in the Western United States are likely to increase in many areas. The West is one of the fastest growing regions, population-wise, of the nation. Growing demands are creating

conficts among agricultural, energy, industrial, municipal, Federal reserved water-right holders, environmental, and other uses and values at particular sites. Increased water-use demands and pressures to shift water to new uses and users and even to transfer across major watersheds suggest that water in the West will become more expensive in the future.

Water quality: Water quality problems are not unique to the arid and semiarid portions of the Western United States. However, the volume of water in the West is smaller than that in the more water-abundant Eastern part of the country; thus any given water use (municipal, industrial, agricultural) has the potential for causing increased water-quality deterioration in the West and for increasing the severity of problems that already exist. Because of the interconnected nature of ground and surface water supplies, contamination of one can eventually affect the quality of the other. Once a ground water aquifer becomes contaminated, relatively little can be done technologically and in a manner that is economically feasible to remove or contain the contaminant.

Most water-quality problems for the West appear to be site-specific. The data base describing the quality of water in the Western U.S. is incomplete, however, and few integrated analyses of water contamination as it affects water reuse, environmental characteristics, or public health have been performed.

Some Western water quality problems result from natural processes. For example, arid and semiarid environments are commonly characterized by high natural levels of salinity in the soils. The sporadic runoff that characterizes these environments often contains high concentrations of "salts" (dissolved materials). It is estimated, for example, that natural sources account for about two-thirds of the total annual dissolved "salts" carried by

the Colorado River; for some portions of this river, concentrations have reached three times the recommended level of total dissolved solids for municipal drinking water.

Other water quality degradation is more directly linked to human activities. Heavy reuse of existing surface flows for irrigation may cause salts to become more concentrated. Other human activities that cause discharge of agricultural chemicals and organic wastes, or industrial and municipal pollution into surface or ground water supplies have increased the potential for western water-quality degradation. Water quality problems in the Western States will directly threaten irrigation agriculture when the water becomes so degraded it requires treatment prior to agricultural use. Increased levels of pollution from agricultural activities will also threaten other uses, particularly the highest quality use, drinking water, with serious consequences for public health and economic development in some areas.

Soil Salinity: Soil salinity--where soils accumulate sufficient soluble salts to impair productivity--is most often associated with irrigated agriculture although nonirrigated lands can also be affected. Soil salinity is a special hazard in the Western States; an estimated 25 to 35 percent of the irrigated cropland in the West is affected by high levels of salinity and the problem is growing due, in part, to intensive land use with inadequate water supplies to flush the salts out of the plant root zone. Excessive salt concentrations can interfere with plant-water uptake, causing water stress even though the soil is wet and result in a reduction in crop yields. In California's Imperial Valley and parts of New Mexico, for example, soil-salinity levels on irrigated land pose a major limitation to crop production.

Institutional and Technological Issues For Sustainable Western Agriculture

In view of these growing problems for Western agriculture, OTA's assessment identified a number of existing and emerging technologies that have potential for sustaining long-term productivity. At the same time, the study found a number of recurring institutional deficiencies that affect the evaluation of a technology's effectiveness and its adoption onsite. These relate to the state of our knowledge about natural processes, the level of cooperation among Federal agencies manipulating resources affecting agriculture, and extent of participation of affected producers and other water users in Government decisionmaking.

Information base: Successful application of a particular technology is site-specific and requires an understanding of the hydrologic cycle and other natural processes involved. However, OTA found that at present the study of Western hydrologic regimes and natural processes affecting agriculture is fragmented and incomplete. For example, the most important source of renewable surface water supplies for much of the West is the mountain snowpack; yet relatively little research attention has been given to this water source. Similarly, rain-fed agricultural systems are likely to increase in importance in view of uncertain water supplies for irrigation; however, research and development has been limited in this area and needs expansion to broader areas including stress-resistant varieties of conventional crops and other crops that are not now domesticated or widely grown. Likewise, research and monitoring of agricultural and health of effects of contaminants in water is needed for national and local decisionmakers to protect water supplies and the public; yet this area has had little research and is currently fragmented, with few regional syntheses of data.

Coordination: A number of agencies are involved with resource management

and science and technology research and development potentially affecting Western agriculture. Yet a framework of coordination and interaction that reflects the interconnected aspects of the natural processes involved is generally lacking. For example, the Forest Service manages timbered lands and the Bureau of Land Management, other public grazing lands; the Bureau of Reclamation manages water once it arrives in reservoirs and delivery systems; the Department of Agriculture studies and advises on water use once it reaches the farm or ranch site, the Fish and Wildlife Service oversees instream flows, the Environmental Protection Agency--drinking water standards, and on and on.

These activities may be on adjacent or distant parts of a river basin or ground water region, and resource responses to manipulation at a particular site may be affected by other activities at adjacent or distant points. While the natural processes are interconnected and interdependent, Federal activities are relatively distinct and separate. In addition, Federal/State and interstate coordination leaves gaps and much potential for improvement. Over the past few years, Federal efforts to integrate water matters to reflect natural processes more effectively have been reduced. The OTA assessment found a substantial need to improve Federal agency coordination and to improve integration of water-related agricultural activities in government agencies.

User Participation: The OTA study found that development and successful application of water-related technologies depend, in part, on the ability of the researcher and user to adapt them to local conditions. Even where the site is physically suited, other barriers may hinder adoption. For example, some practices require large economic investments for equipment, fuel, and labor. The use of some technologies is hindered by institutional factors; water saved by irrigators is often not allowed for their reuse. Some practices are difficult to incorporate into existing farm and ranch operations and in

30-599 O - 84 - 3

some cases require new management skills. A need exists to increase opportunities for western producers to be more involved in decisions about the relevance and practicality of certain technology research and development for arid/semiarid agriculture.

Increased participation in decisionmaking is also needed for those communities and individuals, including Indian water-right holders, who may have important interests in water in the West. Lasting settlement of conflicts over Western water use must involve principles of equity and fairness for current users, for those whose rights have yet to be developed, for those whose communities and lifestyles might be affected by major water shifts, and for new users with economic power who seek to buy water supplies.

Selected Technologies: A key finding of OTA's assessment is that the evaluation of any technology would benefit from analyzing the technology, the hydrologic cycle, and other natural processes in a more integrated fashion than that which now exists. The most promising technologies are based on an understanding of the operation and limitations of the natural hydrologic cycle and how components of the cycle interact at the site of application. Thus, they usually rely on significant amounts of information about the natural processes and their cumulative and interconnected impacts at the site.

As noted above, the presence of technology alone is not sufficient to address the problems of Western agriculture and water use; technologies must be combined with improved data for planning and improved Federal policies and programs that incorporate an integrated approach to resource management. Subject to these considerations, OTA found a number of technologies with particular potential for arid/semiarid agriculture and others with lesser potential because of data inadequacies and current socioeconomic factors. A few are noted below:

Specific applications of biology to the problems of plant and animal water use in arid and semiarid lands have substantial potential. Biological technologies such as tissue culture of rangeland, dryland, and irrigated crops are in commercial use and analogous methods are used in animal breeding. The broader use of native organisms, the domestication of new crops, and new approaches to plant breeding have potential for tailoring agriculture more specifically to arid and semiarid lands, and thus moving beyond conventional approaches where the land and environment are modified for the crop. While many native and new crops show promise, most are faced with major institutional hurdles; general disinterest from the established agricultural community and incomplete research adversely affect their development.

Improved water delivery systems that provide increased flexibility for onfarm irrigation water use are receiving increased interest; existing irrigation facilities and management practices, especially those dealing with release of water from reservoirs, may require extensive modifications before benefits can be realized, however. Many opportunities for improving soil-water conditions exist, but effective use often requires the application of more than one technology in conjunction with skillful management of plants, water, and soil. The extent of the soil-water increase that can be expected with adoption of a particular technology or set of technologies is difficult to quantify given the wide variability in site conditions across the arid and semiarid region.

Improved water-supply forecasting could be one of the most important technologies related to precipitation and runoff in the Western

United States for long-term sustainable agriculture because it directly relates the timing and volume of water available for downstream or lowland agricultural needs

- Opportunities to develop large sources of previously unavailable surface water or to augment existing supplies through such means as construction of new storage facilities, desalination, or interbasin transfers are feasible technologically but are not likely to have substantial potential in the future because of economic, environmental, legal, and social considerations. In contrast, while acceptable verification criteria are still needed, weather modification is an economically attractive augmentation technology that has developed within a solid scientific framework to facilitate future advances.

Selected Options for Congressional Consideration

A recurring theme of the assessment was the need for a systems (or integrated) approach to science and technology research and to institutional decisionmaking regarding policies, plans, and programs affecting the agricultural resource base and water-related technologies. This approach is critical if agriculture in the Western U.S. is to be planned and conducted in a sustainable fashion. As noted above, a number of institutional inadequacies related to research, data analysis and synthesis, coodination, and user participation hinder effective development and application of water-related technologies.

In the past two decades, States have begun to take a more active role in resolving growing conflicts over water use and improving resource management for agricultural and other uses. However, OTA's assessment found that direct

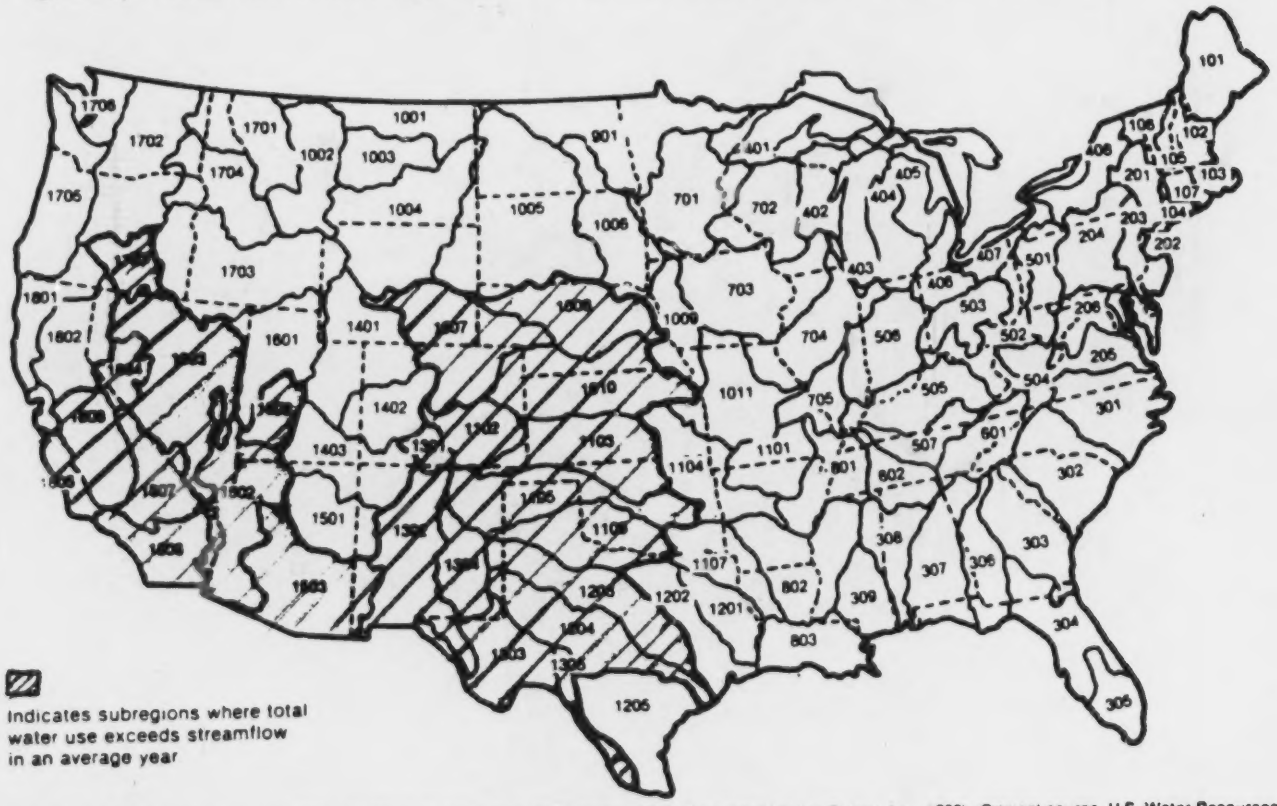
and in some activities expanded Federal involvement was important particularly regarding Federal water issues, topics of a broad geographical and international character, equity concerns, and support with State efforts. The following points highlight some of the major options identified in the assessment for congressional action that are particularly relevant from a national perspective:

1. A need exists for a coherent and coordinated mechanism for the Nation's university research programs in water resources and water-resource management for national, regional, and local problem-solving and policymaking. Congress could establish a National Center for Water Resources Research to serve this function.
2. Improved information is needed by Congress to provide a basis for making decisions and setting goals affecting resource sustainability. Ongoing analysis and synthesis of existing data bases could provide improved information on the dynamics of the resource system and how interactions among resources components affect the sustainability of Western agriculture. A technical unit--e.g., an office of resource analysis--could be established to provide Congress with ongoing quantitative evaluations of the state of the renewable natural resource system as a consequence of near- and long-term congressional policies and Federal programs.
3. Sustaining the long-term productivity of the natural resource base upon which agriculture depends requires an improved understanding of the natural processed involved. Congress could support strengthened research in such areas as the water-producing properties of the mountain snowpack, rain-fed (both dryland and rangeland) agricultural research to expand opportunities for long-term agricultural

productivity on these lands, and comprehensive areawide water-quality research and monitoring of agricultural and health effects of contaminants in water.

4. Water users in agriculture and other activities potentially affected by water-related decisions need increased participation in such decisionmaking. Congress could increase opportunities for participation of Indian reserved water-right holders in both Houses of Congress and could consider establishing a select committee to investigate and recommend legislation to protect the renewable natural resource interests of disadvantaged populations. In addition, Congress could provide mechanisms, though such means as advisory boards, for increased agricultural user/researcher interaction regarding the relevance and practicality of technology research and development for agriculture.

Figure 1.—Water Resource Subregions Where Total Water Use Exceeds Streamflows in an Average Year



SOURCE: K. Frederick and J. Hanson, *Water for Western Agriculture* (Washington, D.C.: Resources for the Future, Inc., 1982) (Original source: U.S. Water Resources Council, *The Nation's Water Resources 1975-2000* (Washington, D.C.: U.S. Government Printing Office, 1978), vol. 2, pt. II, p. 4.)

Table 1.—Western Water Resource Subregions Where Offstream Use Exceeds Total Streamflow

Region number	Subregion number	Name	Months during which offstream use exceeds 90% of total streamflow
10		MISSOURI:	
	01	Missouri-Milk-Saskatchewan	—
	02	Missouri-Marias	—
	03	Missouri-Musselshell	—
	04	Yellowstone	—
	05	Western Dakotas	—
	06	Eastern Dakotas	—
	07	North and South Platte	June-September
	08	Niobrara-Platte-Loup	July-September
	09	Middle Missouri	—
	10	Kansas	July-August
	11	Lower Missouri	—
11		ARKANSAS-WHITE-RED:	
	01	Upper White	—
	02	Upper Arkansas	June-July
	03	Arkansas-Cimmaron	July-August
	04	Lower Arkansas	August
	05	Canadian	July-September
	06	Red-Washita	July-September
	07	Red-Sulphur	—
12		TEXAS-GULF:	
	01	Sabine-Neches	—
	02	Trinity-Galveston Bay	—
	03	Brazos	July-September
	04	Colorado (Texas)	June-September
	05	Nueces-Texas Coastal	—
13		RIO GRANDE:	
	01	Rio Grande Headwaters	July-August
	02	Middle Rio Grande	June-October
	03	Rio Grande-Pecos	March-September
	04	Upper Pecos	April-September
	05	Lower Rio Grande	March-August
14		UPPER COLORADO:	
	01	Green-White-Yampa	—
	02	Colorado-Gunnison	—
	03	Colorado-San Juan	—
15		LOWER COLORADO:	
	01	Little Colorado	—
	02	Lower Colorado Main Stem	March-October
	03	Gila	January-December
16		GREAT BASIN:	
	01	Bear-Great Salt Lake	July-August
	02	Sevier Lake	June-September
	03	Humboldt-Tonopah Desert	February-December
	04	Central Lahontan	August
17		COLUMBIA:	
	01	Clark Fork-Kootenai	—
	02	Upper/Middle Columbia	—
	03	Upper/Central Snake	—
	04	Lower Snake	—
	05	Coast-Lower Columbia	—
	06	Puget Sound	—
	07	Oregon Closed Basin	—
18		CALIFORNIA:	
	01	Klamath-North Coastal	—
	02	Sacramento-Lahontan	—
	03	San Joaquin-Tulare	June-October
	04	San Francisco Bay	July-August
	05	Central California Coast	June-September
	06	Southern California	April-November
	07	Lahontan-South	April, July-September

SOURCE: U.S. Water Resources Council, *The Nation's Water Resources 1975-2000* (Washington, D.C.: U.S. Government Printing Office, 1978), vol. 3, app. III, table III-5.

Mr. SCHEUER. Fine. I think we'll go to Dr. Murino and then we'll have questions for the two of you.

Dr. MURINO. Mr. Chairman, thank you for inviting me here. My name is Clifford Murino. I am president of the University Corporation for Atmospheric Research of Boulder, Colorado. I have a written statement——

Mr. SCHEUER. My subcommittee had the pleasure of visiting your installation last year.

Dr. MURINO. I understand you did, and we'd love to have you come out again.

I am going to be submitting a written statement which I ask become a part of the permanent record——

Mr. SCHEUER. So ordered.

Dr. MURINO. But I don't want to read from the statement. I would like to simply come here and chat with you——

Mr. SCHEUER. Good.

Dr. MURINO. About the creation of a National Center for Water Resources Research. I think the reason you have asked me here is because of our extensive experience in a different field, in the area of atmospheric research, the successful experience we've had some 25 years ago in creation of the National Center for Atmospheric Research, which is managed and operated, as you know, Mr. Chairman, by the University Corporation for Atmospheric Research under sponsorship of the National Science Foundation.

UCAR is a consortium now of 53 North American universities. We just took in recently three additional members, some of the finest university institutions in the United States, as part of our consortium. We manage and operate this beautiful center, NCAR, on the top of Table Mesa in Boulder that is advancing the frontiers of knowledge in atmospheric sciences. I think the parallel between what was true in atmospheric sciences 25 years ago and what exists today in water resources research is striking, and Barbara Lausche has just detailed some of the major problems the Nation is facing in water resources and the problems the university community is having in coping with research in this area.

The universities, as you know, tend to have very high quality research programs, but they tend to be discrete; that is, they are individual pieces of research often in a department in a university. The research going on by one professor bears no direct and immediate relationship to the work going on with his colleagues, each of which are undertaking very high quality pieces of research. The pacing in the universities is normally geared to the time that it takes to get a master's degree or a Ph.D. for the student, so you will see projects that are generally geared to address problems on a 2- to 3-year time scale. Often the universities, of course, don't have quite the kinds of research facilities necessary to make major progress in leaps and strides toward these important—on solutions to the important problems. And then, again, the reward system in the universities for professors and scientists is normally one that means that the professors are going to try to publish as quickly as possible and take on relatively small bites at a time.

Universities themselves tend to be isolated. They tend to work independently. And I think what is needed and what we found was needed in the atmospheric sciences is some nucleus upon which

these university programs can coalesce, so that the universities can begin to work in concert rather than independently, and that we would then have some sort of synergistic effect where the total is greater than the sum of its parts.

In the atmospheric sciences in 1950 we found that the research at the universities was, of course, of very high quality, but was again discrete individual projects, and what was needed was a nucleus for the universities to begin to work in concert, to work in coordinated efforts on large scale major problems affecting the atmosphere. We also needed in atmospheric sciences a center and a focus for the advanced and sophisticated research facilities that were necessary to make effective progress on problems in the atmospheric sciences.

You may recall in the fifties the National Science Foundation characteristically was giving grants of $50,000 to $100,000 to an investigator, and in a situation like that, professors tended to optimize on that $50,000 or $100,000 and they would spend their money in acquiring computing time and aircraft time, whatever kind of research facility was necessary, but in very small bits, and at the end of spending that money and doing good quality work, you ended up really with nothing permanent to show for that. We finally realized that it was time to stop that, to begin to pool those dollars into one place and invest in major advance research facilities that would otherwise not exist.

The net result of that, at least in my field, in the atmospheric sciences, was the creation of NCAR. NCAR is today one of the world's leading research centers. It has made major advances toward solidifying and coalescing the programs at the universities.

In the case of water, we see the parallel is the same. We would like now to, and we are proposing, to create a National Center for Water Resources Research, addressing the same and aimed at the same sorts of problems and benefits that could accrue as accrued in the case of UCAR/NCAR. It is proposed that this Center be operated by a consortium of universities with Ph.D.—offering the Ph.D. degree in water resources programs.

One of the slight differences is that water resources is somewhat more interdisciplinary by its very nature than atmospheric sciences, so you would have a wider spectrum of sciences involved. Also when you deal with the water problems as Miss Lausche has just described, the economic and legal consequences and aspects are often just as important as the physical and chemical sciences, so that staff in the research center in these areas, in law and economics, political science, are very important. So we see this as essentially and largely an interdisciplinary research center, but managed by a consortium of universities, similar, say, to UCAR or analogous to UCAR, but offering the Ph.D. in some of the fields of water sciences. The member institutions would elect a board of trustees. The board would be empowered then to and be the group that does manage the research center under sponsorship of an appropriately chosen Federal agency, but also with funding coming from industry and from the State governments as well. The membership on the board of trustees ought to involve members—people from the member institutions; it should involve representatives from industry and members from the public at large.

We do believe it is very important, though, as in the experience that NCAR has shown, that the program initiative for the center be in the hands of the trustees, in effect, in the hands of the universities, rather than in the hands of the mission or sponsoring agency. That is vital to the quality of the program. We feel that it is a major reason why the quality of the program at NCAR, for example, is so high.

The NCAR, and this new center in water resources, however, would take its priorities not in a vacuum, but by careful evaluation and consideration of the best interests of the Federal Government, the interest of private industry, and the interest of the community at large. Those kinds of factors would go into determining the program priorities. But ultimately and in the final sense it must be in the hands of the board to determine what are the program priorities.

That concludes my remarks, Mr. Chairman. I would be pleased to answer any questions you might have.

[The prepared statement of Dr. Murino follows:]

October 25, 1983

STATEMENT
PREPARED FOR THE
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURAL
RESEARCH AND ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

By

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Mr. Chairman, Members and Staff of the Subcommittee:

I am here at your request specifically to discuss the concept of a National Center for Water Resources Research. The situation that has given rise to this proposal is similar to that in the atmospheric sciences in the late 1950's which led to the establishment of the National Center for Atmospheric Research (NCAR) at Boulder, Colorado, which is operated by the non-profit consortium of which I am President. The atmospheric research community needed a focus for the planning and execution of large-scale, long-term interdisciplinary research efforts. It also needed advanced and sophisticated common-use facilities.

NCAR has answered those needs. It is now one of the world's leading atmospheric research centers. It has greatly broadened the research opportunities available to the university atmospheric science community, has developed advanced and sophisticated research facilities, and has organized, led, and participated in many national and international research efforts.

Through its leadership, it has helped to raise the sights of the research community and to focus the efforts of that community on urgent problems closely related to the national interest.

University research programs tend to be isolated. The NCAR experience shows that a national center can provide the universities with a nucleus upon which their programs can coalesce. The center can thus be a convenient and effective mechanism for the universities to act in concert rather than independently. The result is a synergistic effect where the total effort is greater than the sum of its parts.

NCAR and its managing consortium, the University Corporation for Atmospheric Research, can serve as useful models in the design of a National Center for Water Resources Research. The relationship between UCAR and the National Science Foundation, the Federal sponsor of NCAR, is a useful model of a highly productive partnership between the Federal government and the university research community.

I believe that the establishment of the National Center for Water Resources Research is essential to a powerful national program that can deal adequately with the water resource problems our nation faces. The concept of the national center is a subject of current intense discussion among those university scientists most concerned about our overstrained water resources. Earlier this month, a report of the Office of Technology Assessment, produced

with the advice of many farmers, ranchers, private consultants, government officials, and research scientists, had the establishment of such a center as its lead recommendation.

To provide the information needed to deal with water-related problems, the requisite research must have three qualities: First, it must be directed toward fundamental and applied knowledge and technologies that are of the highest priority. Second, the research must be of high quality and reliability. Third, it must be carried out in pursuit of coherent strategies, often in programs that must have stability and effectiveness over periods of several years to a decade or more. By "coherence," I mean that the individual efforts of scientists are interleaved--for example, the research products of one scientist or a group of scientists are part of the information required by another scientist or group of scientists.

University research efforts are characterized mainly by high-quality, discrete pieces of research geared to graduate study and training. Typically, such projects last two or three years. The subject matter is determined principally by the interests of the faculty member and his or her students. The rewards system in universities also encourages research projects that produce frequent publication. Much valuable research is produced in this way.

A national center can make the necessary additions to this picture. It can order the priorities of its research program. It can establish mechanisms to review the quality of its research and facilities. It can create a resident staff that can make long-term commitments and undertake research that

requires long lead times before publication of results. It can draw in university scientists as research collaborators through a variety of arrangements and for periods of varying lengths.

The center would augment and supplement, rather than compete with, established university programs. Indeed, through its research programs, as well as its facilities, the center can provide new research opportunities.

The research facilities developed and operated by the center would be those that are required to make effective progress on water resources problems, particularly those facilities that require extensive development efforts, are too costly for individual universities to acquire, maintain and operate, and must be deployed in arrays and combinations. Developing and operating at a national center a variety of advanced and sophisticated facilities--computers, data-systems, and laboratory and field measurement systems--is the most cost-effective way to provide these to the research community.

Another important asset of the center will be its ability to bring together--in its resident staff and visitors--the teams necessary to attack interdisciplinary water resources problems and to connect them to real-world concerns. Water resources research is intrinsically interdisciplinary, requiring hydrologists, agronomists, geologists, chemists, biologists, atmospheric scientists, and engineers. Because water resources problems are almost always linked to economic, political, and legal questions, experts in

these areas will play vital roles in the center's programs. In a university, it is difficult, often impossible, to organize this diversity of talent into a coherent interdisciplinary program.

The center would also serve to bring people from private industry and governmental agencies into the research and development programs of the center, in order to provide guidance as to the most important problems to be attacked and to accelerate and make easier the transfer of knowledge and technology to useful application.

Lastly, as the OTA report indicates, the center could serve as an impartial and unbiased information resource for the Congress, the Executive Branch, and state and local governments.

The structure for policy-setting, planning and management of the center is of great importance. Based on the successful experience of UCAR, I see the following attributes as essential to an effective management consortium:

- Its Members should be universities with doctoral programs in disciplines required for water resources research.

- A Board of Trustees, elected by the Member universities, should be broadly representative of the expertise required, and should contain Trustees from the universities, industry, and the national community at large.

- The initiative for proposing the Center's program and for setting priorities should reside in the management consortium.

- In forging plans and priorities, the consortium should rely heavily upon the guidance of advisory groups drawn from the broad community of water resources interests. Due recognition of the needs and priorities of the Federal government in this area of research is essential.

- The allocation of its facilities should be done through mechanisms that ensure equitable and efficient use of the facilities.

- Mechanisms should be established to provide unbiased, expert evaluation of the center's performance.

- The consortium should establish mechanisms for frequent communication with the private sector and government, and these mechanisms should ensure the transmission of information in a form most useful to the recipients.

- It should establish and maintain channels for the effective utilization of scientific information needed in the formulation of public policy.

Mr. Chairman, it is my view, based on over 25 years experience in scientific research and in the leadership and administration of science, that a National Center for Water Resources Research is an essential element in a national effort program to develop and use water resources in the most effective way.

I am ready to provide any further assistance the Subcommittee may desire.

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Mr. SCHEUER. Very good. I appreciate your testimony, also. It was very thoughtful and stimulating testimony.

Now, we have a rollcall vote on there, and I have to leave within 2 or 3 minutes anyway. So why don't I leave now, I'll adjourn, we'll be adjourned for about 12 or 13 minutes, and then we'll, with your indulgence and begging your pardon, we'll come back for some questions, OK?

We'll recess for about 15—a little under 15 minutes.

[Whereupon, the subcommittee was in recess.]

Mr. SCHEUER. We have—going off the record.

[Discussion off the record.]

Mr. SCHEUER. We're going to ask some questions in writing, to round out the hearing report.

Let me ask both of you, though, in establishing the kind of National Water Research Center, Dr. Murino, that you were talking about, would we be starting from scratch or is there an existing university research center that we could use as the nexus or as the center for——

Dr. MURINO. That's a little bit difficult to answer. There is certainly strong existing competence within the university community today. There are, within each of the 50 States, as you may know, Mr. Chairman, water resources centers. I am personally going to be convening the leadership from this group in another few days to try to get them together to see if this proposal is of great interest to them, as it seems like it is now.

We do have, then, existing competence and that nucleus spread in the 50 States. What we don't have is the nucleus, the single, one location that can serve as the nucleus upon which then all of these 50 programs can begin to coalesce and where we cannot have something greater than 50 by simply having a nucleus, something really outstanding and long-lasting to grow as a result of that. So we're not really starting from scratch—the competence is out there—but in terms of creating the new center, that would be starting from scratch.

Mr. SCHEUER. Is there a center of gravity of this research—for example, in certain kinds of telecommunications research, the chips and whatnot, at Silicon Valley, around MIT. Where is the center of gravity of water resources, sophisticated water resources research?

Dr. MURINO. I would say in the arid west, in the Great Basin, if there was a single location. But it really is fairly well dispersed. There is, for example, within your home State, Cornell University has an outstanding program, the University of North Carolina, but then we would look in Nevada, my former home institution, the Desert Research Institute, the University of Arizona, Utah State University, University of New Mexico, and the California institutions all have very high quality programs. These are the ones I think that would begin to pull together. Then, beyond that, we would begin to involve the broader community.

Miss Lausche, do you have any——

Ms. LAUSCHE. Cliff is much better to speak on this, but I agree with everything he said. I think an example of the diversification is just reflected in our authors and our work group and our workshop lists at the end of the report, where we found people from all the

17 Western States, because in this case we were focused on the 17 Western States, but strong individuals and a lot of different institutions and universities across the West that have specialties in a wide range of water disciplines. So I agree with Cliff, that it really is dispersed.

Dr. MURINO. Mr. Chairman, I might add, though, if—again drawing the parallel with NCAR/UCAR, in 1959, when we first created the NCAR, there were 14 charter universities that formed the UCAR. They were broadly distributed around the United States, each with very high quality programs, outstanding programs. But then once NCAR was created, then they became something new and something very special happened to the field. Each of the programs at the universities got that much better as a result of it.

Mr. SCHEUER. At Boulder, or everywhere?

Dr. MURINO. We created it—yes. The programs everywhere got better. Every one of the universities was greatly improved because of what was created and turned out to be located in Boulder.

Mr. SCHEUER. Is there anything we have to learn from a country like Israel, that has a problem of water scarcity—obviously, the whole region does—and where they have shown a strong interest and strong research capability in water resources management? They also have had a very strong foreign aid program in Africa and some parts of Asia, but particularly sub-Saharan Africa. Have they done anything that could show us how to do it or how not to do it?

Dr. MURINO. In some areas they can show us what to do and what not to do; in other areas we can show them what to do and what not to do. It turns out——

Mr. SCHEUER. What would those various areas be?

Dr. MURINO. For example, in the areas of ground water, it turned out that in certain kinds of modeling activities we are advanced, further ahead than they, and that they wanted to then affiliate with us—and when I say us, it turns out it was the Desert Research Institute, my former affiliation. The scientists there had been further along in one area than the Israelis, and they wanted to tie in with us and benefit from that.

They had, on the other hand, knowledge that we wanted, so we established close relationships with the Israelis. We tied in at the present time—the Desert Research Institute is with Hebrew University and with Ben-Gurion University. Close collaboration is going on. And a number of the other universities are doing the very same thing. So there is that kind of collaboration in existence today, extensive collaboration between scientists and scientific programs in the U.S. universities and those universities in Israel that are working in water, working in energy.

Mr. SCHEUER. Are we also carrying on any foreign aid activities in terms of processes and knowledge that is relevant to the typical small-scale farmer in the Third World?

Traditionally, American agricultural research institutions turn out processes and plants and seeds and whatnot for large-scale agribusiness, with almost unlimited ability to invest capital and energy through fertilizer and irrigation and whatnot into farms.

Now, in the Third World there is not such availability of capital or unlimited investments of energy, and what they need are seeds

and plants and fibers that are drought-resistant and need very little water, that are heat resistant and hardy, that don't need large inputs of capital and large inputs of energy.

Is any of the research that we're doing on water management relevant to the Third World countries of Asia and sub-Saharan Africa and perhaps Latin America?

Dr. MURINO. I guess I cannot answer that question specifically, Mr. Chairman. I can try to get further information on that and provide you with it.

Mr. SCHEUER. I would appreciate that a great deal.

Dr. MURINO. I do know of—I have heard of research going on, of course, in the agricultural area—and perhaps you're more familiar with that—that is directed toward precisely the thing you're interested in, in making some of the U.S. technology in agriculture available to Third World nations.

Ms. LAUSCHE. Mr. Chairman, as well in our background paper here that we did as part of the assessment, we highlight some examples where research collaboration and—in fact, activities in other countries could have some benefit here—and some of the stuff we're doing here could have some benefit in especially Third World countries.

We briefly go through the Israeli experience. We also talk about the plant breeding technologies with respect to the cowpea and the bean in Senegal, that where there is interaction between the University of California—I think it's at Riverside—and the plant breeding technologies to improve strains there for heat resistance and drought resistance.

I might also add that some of the findings of this study, while we have this cover that says "U.S. Arid/Semiarid Agriculture," point out some very important aspects for development assistance. If we are saying, for example, that in some areas irrigated agriculture may not be sustainable, and that, in fact, we should be moving more to some of our rain-fed agricultural practices, like dryland and rangeland, if we're looking at development assistance and planning to build major irrigation schemes, for example, in another country, maybe we need to factor in some of the implications that we identified are happening in the United States with respect to irrigation as we begin to examine investments and the types of technology that we want to help other countries develop.

Mr. SCHEUER. Well, I quite agree with you. The kind of irrigation that has served us very well in this country, that is very capital intensive and is very energy intensive, maybe cruelly irrelevant to the needs and limitations of many, if not most, of the Third World countries whom we're trying to help. It may be an act of gross inhuman insensitivity and cruelty for us even to offer them a plant, the kind of plants that call for inputs of energy and capital beyond their wildest capabilities of matching. That would be an act of inhumanity.

My good colleague from Rhode Island?

Mrs. SCHNEIDER. No questions, thank you.

Mr. SCHEUER. Any other questions?

All right. Let me thank you both for your very interesting testimony and your thoughtful and provocative, stimulating answers, and we're going to ask you some further questions in writing. We

will hold the record open for a week or 10 days for you to answer them. I would be particularly interested, Dr. Murino, in the kind of information you said you could put together for me.

Thank you very, very much.

Dr. MURINO. Thank you, Mr. Chairman.

Mr. SCHEUER. All right. Now we'll call the second panel, Mr. Bruce Smith of the Interior Department, Bureau of Land Management, accompanied by David Tidwell, and Dr. Robert Locy, Native Plants, Inc., Salt Lake City, Utah.

STATEMENTS OF BRUCE H. SMITH, DISTRICT FISHERIES BIOLOGIST, ROCK SPRINGS, WYOMING DISTRICT OFFICE, BUREAU OF LAND MANAGEMENT, ACCOMPANIED BY DAVID TIDWELL, SPECIAL ASSISTANT TO THE DIRECTOR, BUREAU OF LAND MANAGEMENT; AND DR. ROBERT LOCY, NATIVE PLANTS, INC., SALT LAKE CITY, UTAH

Mr. SMITH. Mr. Chairman, we appreciate and thank you, your committee and staff, for the opportunity to appear here today to discuss the Bureau of Land Management's riparian management programs——

Mr. SCHEUER. Let's just hold the phone a moment.

What I would like to do—there are two of you who are testifying, correct, Mr. Smith and Dr. Locy, OK? Your prepared testimony will be printed in the record at this point. What I would like for you to do is just chat with us, talk with us, don't read your testimony, please, if you can possibly avoid it. Just chat with us about your ideas, about anything you've heard from the former panel, and then after the two of you have finished chatting with us, we'll have some questions for you. If you can possibly avoid reading your text, it would be an act of Christian charity.

Mr. SMITH. OK. I had a general introduction to kind of organize the outline of my thoughts——

Mr. SCHEUER. Fine. Proceed as you wish.

Mr. SMITH. It will only be two pages, roughly, if that's OK. OK. Thank you.

Stream and riparian management programs of the mid to late 1970's in southwestern Wyoming have identified numerous causes of accelerated erosion and associated loss of riparian rangeland productivity on public lands. Multiple use management efforts of the Bureau are being directed toward the alleviation and mitigation of human-caused impacts and these problems and toward the development of ecosystem engineering techniques for the restoration or replacement of highly productive range sites. The key principle of these efforts has been the reestablishment of naturally stable and functioning riparian ecosystems through improved land management practices as a management alternative to capital intensive physical rehabilitation programs. The most notable results in this area have been the beneficial effects and rapid recovery rates achieved through the application of livestock grazing rest treatments, leading to the recovery of willow populations and their associated beaver-based meadow development and erosion control processes.

The mix of multiple-use activities in Wyoming have placed extensive pressures on many riparian systems, especially in areas which contain erosive soils. In cases where the vegetative or hydrologic stability of the system has been altered, an acceleration of the natural erosion process has resulted. In some cases, within only the past two generations, extreme erosion has occurred along stream channels creating gullies 20 to 50 feet deep. As an example of this loss in rangeland productivity, a recent evaluation of a 30 by 40 mile area south of the town of Rock Springs estimated that 83 percent of the riparian communities existing prior to settlement are no longer present. In livestock grazing terms alone, this lost production is reported to be almost 7,500 months of livestock carrying capacity annually.

Associated with these losses are reduced water quality and reservoir storage due to increased sediment loading, reduced bank storage, and ground water recharge necessary for maintenance of perennial stream flows, resulting in greater peaks during spring runoff and lower base flows during the fall, and subsequently, the ever-increasing need to build more flood control and water storage projects to protect life and property.

The physical integrity and biological productivity of riparian ecosystems are directly associated with a high degree of vegetative cover and diversity and the presence of balanced beaver populations with their associated dam-building activities. Through the construction of numerous small dams, beaver function is a natural and dynamic stabilizing element within the watershed. These dams collect sediment and its associated nutrients, thereby building productive meadows. They help to elevate water tables for a wider, more extensive riparian community, attenuate spring runoff peak flows, extend late season base flows, and serve to structurally alter the morphology of the floodplain and valley floor over time. In short, beaver physically set the stage for establishing a series of biologically productive plant and animal communities.

It must be remembered, however, that this association exists within a fragile balance. Without a minimum quality of riparian habitat, especially willows, beaver will lack the necessary building and food materials for maintenance of a stable watershed and ecosystem.

What I would like to do at this point, Mr. Chairman, is refer to this accompanying posture display here illustrating our district in southwestern Wyoming and just briefly run over some of the projects that are outlined in the report here.

First of all, the public lands that we manage in Wyoming in the Rock Springs District are illustrated by the color yellow on this map. They take in or encompass about 6½ million acres of public lands, 15½ million acres total within our district, Forest Service, private, and other.

One of our first programs in the district was associated with the Thomas Fork drainage, right here. In the midseventies the Utah or Bear River cutthroat trout was thought to be extinct. Investigations, in cooperation with the State game and fish department, found that a pure remnant population existed on public lands and we initiated a habitat management program to try to stabilize these watersheds to preclude the necessity for declaring these spe-

cies as threatened. Today they are at a sensitive status, and on the recovery. Along with these programs, we have gone into extension and cooperative programs with the grazing users to try to improve the range productivity and enter into some model grazing systems on the riparian zone in the sense of applied research, so to speak. To date, the ranchers have requested us to give presentations to their winter coordination meetings on the progress of our studies, the improvement in range productivity, and the Etcheverry family in particular is highly cooperative in our operation of a four-pasture restoration and two two-pasture deferred systems to study the possibility of applied management techniques for stabilizing these watersheds in their entirety.

Second, another one of our programs related to the Colorado cutthroat trout on the east side of the Wyoming range. This is in the country west of Big Piney, which you see in this area here. In this area, once again we had a sensitive rare species of native cutthroat trout. Their status wasn't as critical as the Bear River cutthroat trout, but we initially implemented watershed and stream recovery programs, grazing management practices, to help stabilize this habitat and improve it for the trout. In the process we have expanded these approaches to more cooperation with a few of the more cooperative and progressive range users as well as the Wyoming Industrial Siting Council in their relationships to the development of the Overthrust Belt for oil and gas.

The large area in the center of the map with about 25 or 30 pins was our Sandy livestock grazing study area of about 1978. I believe you can obtain this report from our office. What we identified there was the need to have effective monitoring, riparian monitoring, habitat management programs associated with the development of allotment management plans. As these grazing plans are developed for specific objectives, we felt that in the riparian zone we needed to establish first of all the site potential, the true site potential, for that range site, as well as the effectiveness of the grazing system being applied.

In addition to roughly 20 riparian study and monitoring areas, we have roughly 17 special management areas which are keyed to riparian and wildlife habitat rehabilitation as mitigating measures and improved, again, livestock grazing programs.

Our most recent programs which have received little more attention are located in the southern part of the district, and in these areas we are working on two watershed stabilization projects. The first one, the lower watershed, is referred to as the Red Creek drainage. This drainage is a highly erosive drainage which puts in enough sediment to the Green River in Colorado and Utah to silt that stream bank-to-bank, half an inch deep, for 18 miles annually. We are presently trying to combine techniques of physical stabilization, watershed rehabilitation, and working with nature in the form of applying beaver as a natural element toward stabilizing these watersheds.

The two pins in the upper area in the center, right next to the Flaming Gorge Reservoir, are the focus of our most recent beaver habitat and riparian reclamation studies, which are using beaver through the provision of limiting factors, in this sense, building

materials, in adverse, alien sites to create the physical conditions leading to biological stabilization of 20- and 50-foot deep gulleys.

At the present time, due to nonpoint source pollution associated with phosphorus loading of the Flaming Gorge Reservoir, as a result of accelerated erosion, these beaver are working for us in a really cost-effective manner to keep these nutrients and silt in the upland areas of the watershed, thereby cycling those nutrients into terrestrially based primary production, willows, grass and so forth, instead of algae which is creating a problem in the reservoir at the present time.

More recently, our program activities have involved public extension meetings in small communities throughout the district, as well as cooperative efforts with the University of Wyoming Range Science Department, in relation to program exchanges. We have had workshops with them. Our staff have also prepared class lectures and guest seminars and this sort of thing to them in the botany department to try to bring them up with the current state of our problems and our applied management efforts to try to solve these problems.

Based on the projects that they have worked with us on, at the present time they are trying to develop a statewide research program dealing with restoration of rangeland productivity, especially keyed to beaver, and it's my understanding that they are planning for a sizeable program which has been I'd say 40-percent funded to this point, or have had promises of funding through State channels. I believe EPA may be involved in this as well.

That's all I would have to say at this time. If Mr. Tidwell would have any additions, or do you have any questions, we would be happy to answer them.

[The prepared statement of Bruce Smith follows:]

OCT 25 1983

STATEMENT OF BRUCE H. SMITH, DISTRICT FISHERIES BIOLOGIST, ROCK SPRINGS, WYOMING DISTRICT OFFICE, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR, AT A HEARING OF THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT, COMMITTEE ON SCIENCE AND TECHNOLOGY, UNITED STATES HOUSE OF REPRESENTATIVES, TO EXAMINE WATER-RELATED TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE.

I appreciate the opportunity to appear here today to discuss the Bureau of Land Management's riparian management program for erosion control.

Stream and riparian habitat management programs of the mid to late 1970's identified numerous causes of accelerated erosion and loss of riparian rangeland productivity on public lands in southwestern Wyoming. Multiple use management efforts of the Bureau of Land Management are being directed toward the alleviation and mitigation of the human causes of those problems, and toward the development of ecosystem engineering techniques for the restoration or replacement of highly productive range sites. The key principle of these efforts has been the reestablishment of naturally stable riparian ecosystems, through improved land use management practices, as the alternative to capital intensive physical rehabilitation programs. The most notable results in this area have been the beneficial effects and rapid recovery rates achieved through the application of livestock grazing rest treatments, leading to the recovery of willow populations with their associated beaver based meadow development and erosion control processes.

The mix of multiple use activities in Wyoming, while often desirable from the standpoint of issuance productivity, has often placed extensive pressure on many riparian systems, especially in areas which contain erosive soils. In cases where the vegetative or hydrologic stability of the system has been altered, an acceleration of the natural erosion process

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has resulted. In some cases, within only the past two generations, extreme erosion has occurred along stream channels resulting in gullies twenty to fifty feet deep. Once these streams cut deeper than three to five feet, the lowered water table leads to a loss of the highly productive riparian vegetative community and its dependent uses. As an example of this loss in rangeland productivity, a recent evaluation of a 30 x 40-mile area south of Rock Springs, Wyoming, estimated that 83 percent of the riparian communities existing prior to settlement of the area are no longer present. In livestock grazing terms alone, the lost production is reported to be almost 7,500 months of livestock carrying capacity annually.

Similar losses in riparian-associated rangeland productivity due to erosion have been reported elsewhere in the west. In addition to losses in base production, many water management losses also occur through channel erosion. These losses include reduced water quality and reservoir storage due to increased sediment loads; reduced bank storage and groundwater recharge necessary for maintenance of perennial stream flows; greater peaks during spring runoff and lower base flows during the fall; and subsequently, the ever increasing need to build more flood control and water storage projects in order to protect life and property.

The physical integrity and biological productivity of riparian ecosystems are directly associated with a high degree of vegetative cover and diversity and the presence of balanced beaver populations with their associated dam building activities. Through the construction of numerous small dams, beaver function as a natural and dynamic stabilizing element within watersheds. These dams serve to collect sediment and associated nutrients, thereby building productive

meadows. They elevate the water table for a wider, more extensive riparian community, alternate spring runoff peak flows, extend late season base flows and serve to structurally alter the morphology of the floodplain and valley floor over time. In short, beaver physically set the stage for establishing a series of biologically productive plant and animal communities.

However, it must be remembered that this association exists within a fragile balance. Without a minimum quality of riparian habitat, expecially willows, beaver will lack the necessary building and food materials for maintenance of a stable ecosystem.

The Bureau of Land Management in its Rock Springs District is attempting, through several land management programs, to develop contemporary solutions to riparian habitat and accelerated erosion problems. Examples of these efforts include:

- Development of the Thomas Park Aquatic Habitat Management Plan, featuring two survival areas with instream habitat improvements for the Bear River cutthroat trout, a sensitive species;
- Establishment of multi-discipline riparian recovery and stream stabilization livestock grazing studies;
- Cooperative management with the livestock grazing permittees to rest the entire Huff Creek valley (six miles of stream) through an early season deferment;

- Improvement of cattle distribution through more effective herding, salt distribution and upland water development via pothole blasting;
- Coordination with the University of Wyoming, Range Science Department, for a Master's Degree student studying the correlation of channel erosion parameters as affected by livestock grazing;
- Development and study of beaver habitat management techniques for accelerated rehabilitation of lost riparian systems.

In addition, BLM is conducting an inventory and quantification of riparian habitat and dependent land management values in key areas of mineral development, especially for coal, oil, and gas development.

BLM is also developing several other projects. These include:

- the Sage Creek/Currant Creek Cooperative Habitat Management Plan. Key feature of this plan is development of gully stabilization and riparian rehabilitation techniques utilizing beaver and natural recovery systems.
- the Salt Wells/Pilot Butte Grazing environmental impact statement, with special emphasis on improved livestock grazing management programs, for the enhancement and recovery of riparian habitat and rangeland productivity.
- the Red Creek Watershed Management Plan, with special emphasis on mitigation techniques for minimizing surface disturbance related, soil erosion impacts and evaluation of physical gully stabilization techniques.

- In BLM's Big Sandy Resource Area, the Bone Draw cooperative, including Wyoming Game and Fish Department and local citizen's conservation groups. This involves a stream habitat recovery project, creating the biological basis for establishing an anadromous run of trout, over a distance of approximately 100 miles. This has illustrated the management potential for development of forty miles of a new seasonal fishing and recreational resource on the lower Big Sandy River.

- Sandy Grazing EIS, leading to the establishment of twenty three riparian monitoring units for the purpose of determining riparian site potentials and grazing system responses, and seventeen special management riparian habitat recovery and improvement units.

- Allotment Management Plan for the Acorn Allotment, with special emphasis on riparian recovery and improved meadow production, through the application of a three pasture rest rotation grazing system.

- Prospect Mountain Habitat Management Plan with special emphasis on the physical enhancement of aquatic or riparian ecosystems and livestock distribution through pothole blasting and wetland habitat development.

In the Pinedale Resource Area we have developed the East Front Aquatic Habitat Management Plan, a cooperative (Sike's Act) program between the BLM and Wyoming Game and Fish Department. Key features of this plan include:

- The establishment of four protected survival areas for a pure remnant gene pool of the sensitive status, Colorado River cutthroat trout.

- Cooperation from the grazing permittee of the Upper North LaBarge Allotment, for the provision of a spring/summer deferment to enhance riparian recovery, stream stabilization and beaver ecology within the Rock Creek drainage.

- Implementation of a cold desert riparian rehabilitation pilot study for the recovery of lost range productivity in former riparian sites, presently typified by alkali soils and greasewood communities.

- Implementation of long term aspen management, stream improvement and beaver habitat management efforts for the recovery of Colorado River cutthroat trout, in several streams along the east front of the Wyoming range.

BLM maintains close coordination with the United States Forest Service, the Wyoming Game and Fish Department, and Wyoming Office of Industrial Siting in its land use management and planning in order to provide for environmentally compatible oil and gas development of the Wyoming Overthrust Belt. This includes special attention to stream stability, erosion rates and beaver ecology, as affected by anticipated mineral development activities.

This concludes my prepared statement. I will be happy to answer questions.

Mr. SCHEUER. Go ahead, Mr. Tidwell.

Mr. TIDWELL. The only thing that I would have, Mr. Chairman, is to offer any additional information that the Bureau of Land Management may have in this regard. We have numerous slide shows and other presentations of actual, on-the-ground rehabilitation work that's been done, that are all in line with what Mr. Smith has described to you. But we have similar programs going throughout the West and we intend to accelerate these programs.

We would like to offer an update from time to time, as you wish.

Mr. SCHEUER. Good. Well, I'm certainly impressed with the way you put those beavers into harness, put them to work—below the minimum wage, no stipulation about working conditions, maximum hours, no overtime for Saturdays and Sundays, no medical expense, no coffee hour——

Mr. SMITH. I might mention, sir——

Mr. SCHEUER. That sounds like a good Republican program. [Laughter.]

Mr. SMITH. If you look at the total complexity and mix of land use management problems and needs, as was pointed out earlier, there's quite a bit of overlap in management problems to be solved and diversity of regulating agency. And when the public talks about the regulators slowing them down, I think that applies to the Government programs as well as the beaver.

One reason we have adapted into this program is because by working with natural systems we don't have to get into water filings, water rights, all these political and potentially controversial conflicts, because we're basically trying to stabilize the watershed, restore productivity, and you know improve the management of the land for all people. In this sense, I think——

Mr. SCHEUER. I suppose, if I was a zealot for planning and regulation, I would say well, you had to get a permit as to where you threw all that timber on the ground for the beavers to use, because that's where they're going to build their dam. And if the beavers had to get man's approval for that dam, it would be where you threw that timber on the grass.

Well, we won't get into that, but you have probably given us some important clues for how we ought to proceed to make our entire economy more cost-effective and improve our production and quality control techniques. Maybe we could build a better car and not have to worry about limiting Japanese imports if we could put these beavers to work on some of our Detroit production lines.

OK. That was very, very stimulating.

Let's hear from Dr. Locy and see how you can come up with one better than that. Dr. Locy?

Dr. LOCY. Well, we'll have to see what we can do.

I am here to represent both the private sector in terms of the applications of plant biotechnologies to existing crop plant improvement, and the development of new crops which may have applications to the management and preservation of scarce water in the arid and semiarid regions of the West.

I think before we start, biotechnology is a term that deserves definition, and I know there's a forthcoming OTA report on that in the future, so I don't want to spend a lot of time with that. But in order to have a working definition for today, I would like to define

biotechnology rather simply as the application of new technologies to the solution of biological problems.

Using that kind of a definition, biotechnology has been in existence for decades. Recently, however, it's acquired a great deal of interest based on what might be considered a more specific definition of biotechnology, which would be the application of three specific kinds of technology to the solution of biological problems. In the plant area, these three kinds of technology would include plant cell and tissue culture techniques, which I'll describe for you in a minute, with some materials that I brought with me to help you understand that technology a little better, perhaps; the application of monoclonal antibody technologies, which really have not gained much application in the plant area but have potential application there—and I won't talk about those much in detail—and the third kind of technology is the applications of genetic engineering or recombinant DNA technologies to crop plant improvement.

Turning to tissue culture technologies for a moment, there are really three systems of tissue culture which form what we call the plant tissue culture area these days. The first kind of tissue culture system is shoot tip or maristem culture situation, and that's represented by this plate.

Can I get that up there?

And on that petri plate, what you have are some shoot tips which have been cultured, placed in culture and which will start multiplying and produce many, many more plants precisely genetically identical to the original plants form which those "explants", as we call them, the pieces of tissue placed in culture were taken.

The application of this technology is now really state-of-the-art in much of horticulture as a way of rapidly and conveniently propagating many kinds of plants. For example, you can go to any local chain store nowadays and buy a Boston fern, which has been propagated using that kind of technology. We at Native Plants, the firm that I work for, have developed technologies for doing clonal propagation of jojoba plants and of the four-wing salt bush, which are two plant materials native to arid and semiarid regions in the West that have application as potential new crop species, and we can identify existing elite genotypes in the wild and propagate those to place into commercially agricultural—agriculturally commercial plantings.

The second kinds of plant tissue culture technologies which are applicable involve the use of tissue or calluse culture techniques, and this second plate I have for you is an example of a calluse culture. Why don't you take this one, too, Barbara, at the same time, to save you a trip.

The plate that you see which has calluse growing on it, and the subsequent flask containing a cell culture system, are two examples of a more advanced kind of plant biotechnology which has not yet reached wide application. One prepares the liquid culture from the other culture that you see there, and these two kinds of technologies depend on the ability to place in culture and initiate those kinds of tissues, make them grow in culture, and then regenerate, as we call it, or form a plant back from those cells growing in culture.

The advantage to these technologies are that one can screen in the culture system for a genotype of interest—for example, potentially a herbicide resistance or a disease resistance, or the ability to grow in the presence of salt, or the ability to grow in the presence of drought, could all be things that could be screened for in the culture vessel. Once one has obtained a cell line which grows very effectively in culture under those stressed kinds of conditions, a whole plant can be made from it and used as the basis for either a breeding program or a new crop. So that's one kind of way that biotechnology would purport to develop new crop practices in the future.

Molecular biology or gene splicing or genetic engineering is also an additional technology that has been given a great deal of public attention recently and has been touted as the potential salvation of the continuing improvement of crop species. Those technologies all revolve around being able to develop whole plants from even a more, so to speak, broken down kind of culture than the systems that we see here. One takes the wall off a plant cell and forms what is called a protoplast. Into that protoplast, one can introduce genetically engineered kinds of variation and then regenerate plants from those.

The ability to move a gene into a plant and get it expressed at the whole plant level was reported earlier this year, in 1983, and I think the development of that technology has proceeded much more rapidly than most people in the plant sciences area would have expected it was going to.

As such, the research areas that I would like to emphasize for you that I think need a great deal more attention in terms of research programs is really the process of being able to develop a whole plant from these cultured kinds of systems. That type of research really is the limiting factor in the application of biotechnology to a wide range of crop plants.

The second area I would like to turn your attention to, then, having told you a little bit about biotechnology and some of the things it can do, is its applications to conventional plant breeding schemes. Generally speaking, what plant breeding does is create a pool of genetic variation, and then screened from among this pool of genetic variation that was created, those individuals which have the genotypes or phenotypes of interest to the agricultural community. Once the genotypes have been selected from the pool of genetic variation, they are tested against existing crop materials to see if they have a better field performance than what the existing crop materials do.

Biotechnology really has the capacity to create new kinds of genetic variation and has the capacity to aid in the selection and screening of the genetic variation that has been created. As such, it doesn't constitute a conflict of any kind with conventional plant breeding, but just another tool in the arsenal of the plant breeder for the development of an improved genotype of an existing crop or of a new crop.

I think that in a few years we will find that biotechnologists, including molecular biologists and plant tissue culturists, will be working with plant breeders the way plant pathologists and entomologists, for example, work with plant breeders today.

The third point then I would like to address is specifically a few examples of the applications of biotechnology to crop plant improvement. These applications include selecting for improved salinity tolerance or salt tolerance; selecting for improved drought resistance and selecting for improved water use efficiency using the technologies. In order to apply biotechnology to any given crop improvement problem, we need to understand, at as detailed a biochemical and physiological level as we possibly can, what the factors involved in a plant's ability to tolerate the kind of stress or the kind of problem we're attempting to solve are.

The factor which is limiting, I think, the application of biotechnology in the plant sciences in general is the fact that we do not have adequate background knowledge upon which to base the applications of these technologies.

Programs, for example, in the case of applications for arid and semiarid land development, programs, I think, are needed into the basic research fundamentals involved in a plant's ability to tolerate water use in salt, in drought conditions.

I think that's basically the extent of the remarks I need to address.

[The prepared statement of Dr. Locy follows:]

THE USES AND APPLICATIONS OF PLANT BIOTECHNOLOGY FOR WATER RESOURCE MANAGEMENT IN THE ARID AND SEMIARID WEST

There are three topics which this statement will cover. These are: first, to define biotechnology; second, to discuss the application of biotechnology to the improvement of crop plants; and third, to discuss the application of these techniques to the problems of the arid and semiarid lands in U. S.

What is Biotechnology?

A definition of the term biotechnology might be--the application of new technologies to the solution of specific biological problems. Using such a broad definition, biotechnology has been in full force as a commercial reality for several decades, especially in the medical and agricultural fields. However, in recent years the term has taken on a more limited meaning relating to the applications of three specific technologies to the solution of biologically based problems. These technologies include plant cell and tissue culture technologies, monoclonal antibody technologies, and molecular genetic or genetic engineering technologies. Such a definition may be unduly narrow, but it is appropriate for this discussion since these are the areas which hold much promise for the future genetic improvement of existing crop plants and the development of new crop plants (including trees, shrubs, and herbaceous horticultural and agricultural plants).

Plant cell and tissue culture technologies can be grouped into three areas. These are shoot tip and meristem culture techniques, callus and tissue culture techniques, and single cell and protoplast culture techniques. Shoot tip culture techniques are presently being used to propagate a number of superior types of plant materials. For example, at NPI we have developed such procedures for superior types of jojoba and four winged saltbush, two crops suited to dry-land agricultural application in the arid and semiarid regions. Such technologies are now widely available for a large number of plant species. The other tissue culture technologies listed above have not yet attained the commercial application that shoot tip culture techniques have, and the development of these technologies for a wide range of crop species is currently one of the limiting factors in the application of all areas of biotechnology to crop improvement.

The demonstration that DNA can be specifically cleaved into fragments which can be multiplied in bacteria by a process referred to as cloning has provided the basis for what is now referred to as genetic engineering. The potential application of these techniques to crop plant improvement has generated much interest from both public and private research funding sources. The recent demonstration that a gene can be cloned, transfered to a plant, and heritably expressed at the whole plant level suggests that this area of biotechnology is advancing much more rapidly than most plant scientists would have expected.

The applications of biotechnology in plant breeding

Agriculture began when prehistoric man attempted to grow rather than gather his food needs. Fundamental to the very beginning of agriculture was the notion that only the best materials found in the wild should be cultivated. Thus, the principles used by the earliest "plant breeders" are basically the same as those practiced by modern breeders. These principles include: 1) the

establishment of a pool of genetic variation which is actively being recombined to yield novel genetic combinations, 2) the selection and screening from this genetic variation pool of those materials having desirable combinations of traits, and 3) the testing and evaluation of the field performance of these materials.

Despite the fact that the basic principles underlying crop plant improvement may not have changed dramatically across the past several thousand years, modern plant breeders have been responsible for substantial increases in agricultural productivity across the past 50 years. This success has been based on the development of powerful new methods for statistical evaluation of field performance, on the development of quicker and more reliable methods of screening and selection, and on the use of increasingly larger and to some extent more varied populations of genetic variation.

The application of the tools of biotechnology to crop plant improvement should not be viewed as being competitive with or as a replacement for conventional plant breeding, but rather as the latest additions to the arsenal of techniques which a breeder can use to both generate and screen genetic variation. It is quite reasonable to predict that in the next 5-10 years most plant breeders will be working with molecular biologists and tissue culture scientists in much the same way they now interact with entomologists and plant pathologists. The competitive nature of private sector plant breeding and the potentially dramatic advances to be made by the application of biotechnology in crop plant improvement will facilitate such interactions.

The application of the techniques of biotechnology in plant breeding is at present limited by our understanding at the biochemical and cellular level of the physiological processes limiting productivity. This is particularly true in areas related to plant water utilization, a point to be further developed later in this statement. In order to fill this void of knowledge a substantial funding commitment to basic plant sciences which has traditionally been lacking is needed. The interest and commitment of the private sector in this area is exemplified by the fact that there are now over 30 plant biotechnology-based small businesses in the United States, and many large companies in agricultural products markets also have plant biotechnology components. In the last 5 years several governmental programs to fund basic plant science research have been established, but both the scope and the scale of these programs are limited. These programs need to be expanded and additional programs need to be added if the background needed to feed the "biotechnology revolution" is to be developed.

<u>The application of crop plant improvement and biotechnology to the development of sustainable agriculture in the arid and semiarid west</u>

With diminishing water supplies and increasing water quality problems facing irrigated agriculture in arid and semiarid regions, and with a new interest in cropping marginal lands, there is an increasing demand for plant materials which can make the most efficient use of available water, and tolerate periods of drought or increased soil salinity and remain productive. Rain-fed agriculture has not been characteristic of western agricultural practice due to abundant and cheap irrigation water. As a consequence, plant improvement efforts in the region have concentrated on solving problems of more immediate concern such as low yield and disease and other pest problems. Attempts to develop both more water-use efficient and more salt tolerant crop

plants have been minimal. Also the utilization of highly productive native plants or dry-land adapted species from other parts of the world as potential new crops has only recently been considered. Biotechnology can play a critical role in the identification and genetic exploitation of these materials both as new crops and as sources of germplasm for the improvement of existing crops. It should again be stressed, however, that this is an underfunded area of research and only if research programs are developed in this area will the full potential of the technologies be realized.

An example of a potential new crop species which is being developed following the above principles is grain amaranth. It is known that amaranth species are among the few broadleaf species which utilize a water-use and photosynthetically efficient pathway of photosynthesis. By better understanding both the physiology of water utilization and photosynthesis of amaranth and the factors which currently limit its agricultural utility, the techniques of biotechnology can be used to rapidly develop grain amaranth as a new crop species for areas where irrigation water is in short supply and/or of poor quality. Other possible new crop species where such strategies may be workable are listed in the OTA report "Water-Related Technologies for Sustainable Agriculture in the U.S. Arid/Semiarid Lands."

In the preceeding remarks the need for additional basic research in the plant sciences has been stressed. My rationale for making such a strong case for this point is that nowhere in the plant science area is such basic understanding more needed than in the areas of plant water relations, drought stress adaptation, and salt stress adaptation. It is in these three areas that biotechnology and conventional plant breeding can make dramatic contributions to the sustainability of agriculture in the face of diminishing water supplies in the next decade. The mechanisms for governmental funding of basic plant sciences research in these areas deserve careful attention in light of the limited research funds available for plant sciences and the strong private sector involvement in the development of biotechnologies. Programs such as Small Business Innovation Research programs and University-Industry Cooperative Research programs can be particularly useful in facilitating the development of the basic research tools necessary to provide rapid growth and implementation of biotechnologies in these areas, but funding for such programs should not be at the expense of competitive, university-based programs. Proper coordination of such programs will make funds spent on basic research in these areas cost effective and fruitful in the near term, as well as contribute to a sustained arid land agriculture in the west.

Mr. SCHEUER. When you go to Africa and you talk to them about the need for bringing some kind of equilibrium between food production and people—they have an exponential population growth rate in all parts of sub-Saharan Africa—you frequently get the answer, "We don't have a people problem; we have a land problem." They'll wave toward their vast arid wastelands.

Do you see any water management techniques coming down the pike, or any other scientific techniques, bioengineering, or anything else, that will enable us to bring back to productivity these utterly arid, nonproductive deserts that cover so much of sub-Sahara Africa?

Dr. LOCY. Well, a plant faces a fundamental dilemma. It's got to open a hole in its leaf to take CO_2 in in order to make the food that it needs to grow. In opening that hole, called a stomate, in its leaf, it lets water out. The productivity of any plant in any ecosystem is directly dependent on the amount of water that's available. So the notion that we're going to create systems that allow us to farm the Sahara Desert the way we farm the middle of the Corn Belt in Iowa, frankly, I think are really quite limited. The notion, however, that we can develop plants that are capable of tolerating prolonged periods of drought, that are capable of tolerating excess soil salinity, that are capable of tolerating or using the water they're given as efficiently as possible, are really, I think, are that need pursued. And the notion that the plants that grow in those areas and do create an amount of biomass each year when they've got the water to do it may be the productive approach to use.

For example, an area that I neglected to mention in my testimony, which is—in my verbal statement—which is covered in the submitted testimony, is a crop that we're working with called grain amaranth. I have a small sample of grain amaranth seed for you to look at here, too.

Grain amaranth is a plant which does a particular kind of photosynthetic biochemstry which makes it very water-use efficient, and which makes it very photosynthetically efficient. In other words, it doesn't have to open the holes in its leaf so wide in order to get the CO_2 that it needs because it can concentrate its CO_2. The notion of looking at things of this nature, which are plants that grow in these areas, and trying to cultivate them as productive individuals in rangeland situations or as productive individuals in a limited cropping system, for example, we would see this crop as something that could be grown in areas of both this country and other countries where water supplies are increasingly limited. Perhaps areas where the Ogallala aquifer is drying up and where irrigated agriculture can no longer survive this crop could go in, be given a shot of water early in the spring to get it out of the ground. Once it survived and geminated in the environment, it could grow on whatever water came along naturally and produce the type of seed that you see there, which could be either consumed as a sort of human nutrition or consumed as a source of animal feed.

I think the key is to look at the resources that already exist in the area and how they tolerate the conditions that they have to tolerate. Again, I think I need to stress that we need a basic understanding of the physiology and biochemistry that allows those species to survive, that allows them to be productive in the environ-

ments that they are in, and that will provide the key both for the development of those things as crop plants and the key for understanding how to make our existing crop plants more water-use efficient, drought tolerant and salt tolerant.

Mr. SCHEUER. We have 30-odd biotechnology firms in the United States——

Dr. LOCY. Yes.

Mr. SCHEUER [continuing]. I take it, who were involved in——

Dr. LOCY. Thirty small business-type biotechnology firms, several other large firms involved as well. I should say plant biotechnology firms, too.

Mr. SCHEUER. Plant biotechnology firms, yeah.

Were they developed because of Federal support for this kind of research, or in spite of the lack of Federal support?

Dr. LOCY. I think in spite of would be the appropriate way to say it. The commitment that the private sector has made to the development or to the potential development of biotechnologies in the plant area is, I think, like in excess of $1½ billion it totals up to, and the total Federal budget, as I understand it, based on statistics that I've seen, for agricultural research as a whole is something like $700 million annually.

Mr. SCHEUER. Yeah.

Dr. LOCY. The basic research component of that is even a few percent of that $700 million figure.

Mr. SCHEUER. I take it you feel that there's a real role for the Federal Government in supporting this kind of rapidly changing and rapidly evolving research.

Dr. LOCY. Yes, I do. I think the role is to support the basic programs which will be applicable to biotechnology to lead to the development of things that will directly benefit the public. What we lack is the basic understanding of the processes that are going on in plants to be able to really determine what problems to approach with our biotechnology. I think the goal of the Federal——

Mr. SCHEUER. So you lack the basic research. You're really in the applied research business, I take it?

Dr. LOCY. I think that that's the role the private sector should play and I think the role the public sector should play is the development of the basic research needed to fulfill that. I think it's an area whose time has really come, sir. I think that if you look at the problem you will find that money spent in basic plant research right now stand to lead to developments that will be of tremendous benefit to the society, to society as a whole in the next 5 to 10 years. Probably at no time in the history of plant science has the opportunity for money spent on basic research—has the opportunity for those moneys to be directly productive, I think—been so great as it is right now. There is a tremendous opportunity there.

Mr. SCHEUER. You're saying there will be a tremendous payoff——

Dr. LOCY. Yes, I think so.

Mr. SCHEUER [continuing]. For every dollar spent on basic research, and the gains from applied research that people like you can accomplish.

Dr. LOCY. And it's because biotechnology is really waiting in the wings to take any information that basic research provides us with and run with it right now to produce something that will be of benefit.

Mr. SCHEUER. So you're basically envisaging these centers that we talked about, centers for further basic research?

Dr. LOCY. Yes, sir.

Mr. SCHEUER. Do you have any working arrangements with agricultural experimental stations or perhaps land grant universities to provide you with basic research that you could work with and then, in turn, to use the new crops and the new seeds and the new techniques that you would be developing?

Dr. LOCY. We have a number of kinds of relationships that could be spoken of. The amaranth project that I discussed with you briefly that we're working on is being developed in conjunction with the University of Utah. It's being developed as part of a National Science Foundation-university-industry cooperative research grant. So that's one example.

Another example is the fact that we independently, as a company, fund basic research with several university researchers in other universities in order to get basic research underway that we feel is fundamental to the development of our technologies. In addition to that, we receive funds from small business innovation research programs in the past, and I think that's a viable option that needs to be given continued consideration. I think it's through those kinds of programs that the funding for this kind of research can be directed at addressing the problems in basic research that are needed in order to solve applied problems.

I would also urge that I don't think those kinds of programs should be funded at the expense of cooperative university-based programs because I think the best scientific minds in the country, by and large, are located at universities. Applying those minds to the solution of these problems is a very important consideration that needs to be made, I think.

Mr. SCHEUER. Well, it has been very, very interesting, Dr. Locy. You have really opened our eyes to the need for this, or have stimulated us even further as to the need for this. I think that I had some degree of awareness that there was a real payoff possible, especially in techniques and processes and seeds and whatnot, plant varieties, that were appropriate for the small-scale farmer, both in this country and abroad, who does not have available large inputs of capital and fertilizer. We have gone over this and I don't have to say it again, but you're revalidating my belief that some major breakthroughs are possible, and it seems to me that we ought to get on with the job.

The food and agricultural organization just put out a report that was widely printed about a week ago, showing that in sub-Saharan Africa there is unspeakable tragedy facing us from the desperate food shortages and their exponential population growth rates. It seems to me that people like you may have part of the answer and we ignore you at our peril.

So thank you very, very much for your testimony, and we'll have some further questions for you in writing. We are very grateful to all of you for your patience in putting up with the delay. With our repeated thanks, we'll adjourn this meeting.

[Whereupon, at 3:30 p.m., the subcommittee adjourned subject to the call of the Chair.]

APPENDIX

QUESTIONS AND ANSWERS SUBMITTED FOR THE RECORD

WITNESS QUESTIONS FOR MS. BARBARA LAUSCHE

GROUNDWATER SHORTAGES

1. ON PAGE 3 OF YOUR TESTIMONY YOU STATE SURFACE WATER SHORTAGES EXIST ANNUALLY IN SOME PORTION OF EACH OF THE MAJOR WATER RESOURCE REGIONS OF THE WESTERN STATES.

   A. HOW SEVERE ARE THESE WATER SHORTAGES?

   B. IF THE PRESENT CONDITIONS CONTINUE FOR TWENTY YEARS, HOW SEVERE WILL THE WATER SHORTAGES BE?

   C. DO SIMILAR PROBLEMS EXIST FOR THE FARMER IN THE EAST?

2. ON PAGE 3 OF YOUR TESTIMONY, YOU INDICATE THAT GROUNDWATER USE IN THE WESTERN U.S. ALMOST TRIPLED BETWEEN 1950 AND 1975. AT THE SAME TIME GROUNDWATER USE OCCURS FASTER THAN RECHARGE OF THE UNDERGROUND AQUIFERS.

   A. WILL THE CURRENT SUPPLY OF GROUNDWATER ALLOW US TO CONTINUE TO USE IT AT THE PRESENT RATE FOR THE NEXT TWENTY YEARS?

   B. WHAT IS THE CURRENT AMOUNT OF GROUNDWATER AVAILABLE FOR AGRICULTURE USE?

C. IS IT POSSIBLE FOR CURRENT TECHNOLOGY TO RECHARGE GROUNDWATER AQUIFERS?

WATER QUALITY

3. YOU INDICATE ON PAGE 4 THAT MOST WATER-QUALITY PROBLEMS (OR POLLUTION) APPEAR TO BE SITE-SPECIFIC.

A. PLEASE GIVE US SOME EXAMPLES OF THE TYPES OF POLLUTION THAT ARE AFFECTING AGRICULTURE.

P. 6

B. DOES THE FARMER IN THE EAST, FACE SIMILAR PROBLEMS? PLEASE EXPLAIN.

C. WHAT WILL BE THE STATUS OF WESTERN WATER QUALITY IN TWENTY YEARS?

4. ON PAGE 5 YOU INDICATE THAT THE INCREASED SALT IN THE SOIL IS A MAJOR PROBLEM IN PARTS OF CALIFORNIA AND NEW MEXICO.

A. HOW EXTENSIVE ARE SOILS SALINITY PROBLEMS IN THE WEST?

B. IS THIS ALSO A PROBLEM IN THE EAST?

C. WHAT CAUSES THESE SOIL SALINITY PROBLEMS?

D. HOW CAN LAND THAT HAS HIGH SALT CONTENT BE RECLAIMED FOR AGRICULTURE USE?

LONG-RANGE IMPACT

5. BASED ON THIS TWO-YEAR STUDY, IF NO ACTION IS TAKEN TO CORRECT THE CURRENT WATER PROBLEMS, WHAT WILL AGRICULTURE AND FARMING BE LIKE IN 20 YEARS?

A. WHAT POLICY CHANGES CAN WE MAKE NOW THAT WOULD CORRECT THESE PROBLEMS?

POPULATION

6. THE POPULATION OF THE WEST WILL INCREASE OVER THE NEXT TWENTY YEARS.

A. HOW WILL THIS IMPACT THE WATER QUALITY? QUANTITY?

B. HOW WILL THIS EFFECT AGRICULTURE? WATER USE?

Response to followup questions from testimony of Barbara Lausche, Office of Technology Assessment, on October 25, 1983 before the House Subcommittee on Natural Resources, Agriculture Research, and Environment of the Committee on Science and Technology:

The following supplemental information to the testimony identified above is excerpted and summarized from the OTA assessment "Water-Related Technologies for Sustainable Agriculture in U.S. Arid/Semiarid Lands." That study did not include any in-depth analyses of eastern problems; however, where it is possible to extrapolate information from the study to the East in response to specific questions this will be done.

1. Regarding the severity of the surface water shortages in the western States:

Surface water supply problems in the western States are site-specific and depend upon the demands for water at a particular site and time in relation to the available supplies at that site and time. A number of analyses exist on "dependable" supply; commonly these analyses are based on annual amounts of consumptive water use and streamflow. The use of annual aggregates to determine the water-supply/use patterns of the western United States often obscures the seasonal nature of many of the shortages that characterize the area, however. Therefore, monthly estimates of supply have also been calculated for the 52 water-resources subregions of the western U.S.

The Second National Water Assessment found that in 26 of the 52 subregions, offstream water use exceeded 90 percent of the average monthly supply during at least 1 month each summer. (These subregions are identified in table 1 of my submitted testimony.) These subregions are

generally located in areas experiencing water-supply problems. The areas experiencing at least 1 month of a water-supply deficit during each summer are southern California; the Great Basin; portions of Arizona, New Mexico, Colorado, Nebraska, Kansas, Texas; and the Snake River Plain in southern Idaho.

Water consumption of many of the subregions of the West actually exceeds 90 percent of streamflow during more than 1 month of each year. This suggests that no excess surface water is available during at least August in the western States; even in the Pacific Northwest water that is not used offstream is required for instream hydroelectric generation. Depending on the water-resources region, during periods of surface water shortage existing demands are met by reuse of surface waters and ground water withdrawals.

It is difficult to predict the degree of severity of these problems in 20 years if current conditions persist. This is because national data are scattered and incomplete regarding impacts at the local level of increased competition for existing surface water supplies. Moreover, synthesis is rare causing predictions to involve assumptions and extrapolations that, in view of existing data, may make the results difficult to use in a meaningful way.

Conflicts over use are already causing water supply shifts and allocation adjustments. For example, Arizona has legislated certain ground water management criteria that give increased attention to nonagricultural uses and facilitate shifts in that direction. Particularly in those agricultural areas where increased demands are being met by ground water "mining," rising energy costs for pumping are having an increased impact on production profits and in some areas have reduced

the economic feasibility of irrigation. In areas of intensive urban and suburban growth, priorities for water use may change with the interests of the voting population.

In the more water-abundant eastern U.S., total water use does not generally exceed streamflows in an average year. (See figure 1 of the submitted testimony.) The availability of supplies in the amount and at the time needed is an ongoing problem for agriculture, though in contrast to the West the eastern water management problems may be most severe in relation to managing excess supplies rather than deficits.

2. Regarding ground water use, availability, and technologies for recharge:

Ground water resources have become increasingly important to western agriculture in the past decades, since increased use of ground water has allowed large new areas of land to be irrigated. A wealth of information exists on ground water supplies and quality in individual aquifers and at particular sites in the West. But regional synthesis of this information is seriously lacking. The recent trend toward sophisticated computer models has produced a competence for detail, but has exacerbated the problem of gaining an overview of this resource for western agriculture and other uses.

The question concerning available ground water supplies for agriculture must be addressed within the broader context of the feasibility of using available supplies in view of energy costs. In the 1960's and early 1970's, when the rate of withdrawal and overdraft were rising rapidly, concern grew over the effect of pumping on the long-term availability of ground water for irrigation. More recently, the fear of depletion has been displaced by the much more immediate concern that

energy prices will make irrigation with ground water uneconomical in some areas, even with much of the water still in the aquifer. When water must be lifted several hundred feet, energy costs tend to be the major component of water costs.

Technologies to improve the efficiency with which ground water can be pumped from underground sources are necessary to compensate for rising energy costs and declining water levels. In addition to changing the spacing and depth of wells drilled into the aquifer, the technologies involved are generally concerned with the type of pump employed and the fuel or energy source used to drive the pump. Technologies for improving the efficiency of the water well itself also may be important in certain cases.

Technologies for recharging ground water aquifers include water spreading and the use of recharge wells or pumping to induce recharge from natural surface-water bodies. The choice of a given method, or combination of methods, is highly site-specific and will be governed by local topographic, geologic, climatic, and soil conditions; the quantity and quality of the water to be recharged; and the ultimate use for the water. A fundamental requirement for artificial ground water recharge is that excess water be available, either locally or by import into a region, during all or part of each year. In some areas that appear to have no water supply excess--e.g., southern California and central Arizona--wastewater is increasingly used for ground water recharge, and this practice has implications for the quality of receiving supplies as noted below.

The two primary limitations on the application of water spreading are the availability of land and the availability of unappropriated surface

water. In many areas of the western U.S., one or both of these will effectively make the technology infeasible. A further limitation is the lack of a suitable geologic setting. Recharge basins and pits will work well only with a near-surface, unconfined aquifer or in a natural recharge area of the aquifer.

Recent studies on the use and success of recharge wells are scarce. A few regions in the western States have experience with this technology. In California, where artificial recharge is practiced most extensively of the western States, one study has shown an annual recharge of approximately 1,100 acre-ft/yr for a single well in the San Joaquin Valley, but stresses the lack of experimental data. Another study gives average values ranging from 200 to 400 acre-ft/yr for six sites in southern California.

For most aquifers, artificial recharge rates using recharge wells seldom equal pumping rates. The difficulty lies in the fact that pumping and recharging differ by more than just a simple change in direction. As water is pumped from a well, fine material present in the aquifer is carried through the coarser particles surrounding the well and into the well where it is removed with the extracted water. In the reverse direction, any silt carried into a recharge well will be filtered out by the coarser materials and will tend to clog the aquifer surrounding the well. Dissolved air carried to the aquifer by recharge water will similarly tend to clog the well. Bacteria, which will be a much more common constituent of recharge water than of natural ground water, can form growths on the well screen and the surrounding rock or soil, thereby reducing the effective recharge area of the well. The chemistry of the recharge water may not be in equilibrium with the aquifer or the natural

ground water, thus producing chemical reactions that may reduce the permeability and porosity of the aquifer. In general, ground water recharge using wells will only be suitable for high-quality, treated water, and considerable experience is required to maintain optimum recharge rates. The recharge well is a technology that is limited to situations where there are no other options.

3. Regarding water quality:

The types of possible water pollution are varied and can arise from different uses. They can be summarized in eight general categories:

1. municipal sewage and other oxygen-demanding wastes,
2. infectious agents,
3. synthetic organic chemicals,
4. inorganic chemicals and mineral substances,
5. sediments,
6. plant nutrients,
7. radioactive substances, and
8. heat.

As noted in the testimony, water quality problems are not unique to the West. However, smaller volumes of water in the western States, as compared with the more water-abundant East, increase the potential that any given water use in the West may cause serious water-quality degradation.

Because research and data are currently so fragmented and incomplete regarding western water quality problems, it is difficult to be quantitative on the severity of future problems. Agricultural water pollution can be reduced by using improved management practices and

methods that result in fewer contaminants being released into the water supply. However, OTA found that present monitoring and control measures may not be sufficient to prevent deterioration of water quality caused by Western water use for either agricultural or nonagricultural activities--e.g., municipal and industrial activities. The study suggests increased research on and synthesis of data on agricultural and public health impacts of water quality deterioration and increased efforts to implement nonpoint source pollution control measures.

4. Regarding salinity problems:

Soil salinization can occur in two ways--either insufficient irrigation water is applied or drainage is inadequate. When one of these problems exists, whether in the western or eastern States, salinity may become a problem. In the first case, as irrigation proceeds and water (containing salts) is added to the soil, pure water evaporates or is transpired by plants, and salts remain in the soil. Soil weathering, accelerated by irrigation, also contributes salts to the soil solution. Unless these salts are periodically flushed by rain or by excess application of irrigation water, the salt content of the soil will gradually increase and soil salinization will occur. In the second case, where drainage is inadequate, salinization occurs as repeated irrigations raise the ground water table, and capillary rise carries water close to the soil surface where it evaporates, leaving a salt residue.

As noted in the submitted testimony, salinity is a special hazard in the western States--with an estimated 25 to 35 percent of irrigated land affected by high salinity levels. Leaching, whether by periodic flushing or adequate irrigation, can mitigate the effects of salinization.

However, flushing requires extra water supplies which may not be available at the problem sites in the West. Other management methods include precise land leveling of fields to enable flood, rather than furrow, irrigation, and where land leveling is impractical, sprinkler irrigation with carefully timed and measured amounts to maintain downward movement of salts and favorable growing conditions for the plant.

5. Regarding long-range impacts:

Currently, agriculture (farming and ranching) is the dominant land use in the western United States. Products of western agriculture constitute a large share of the total income derived from agriculture in the U.S.--in 1980, about 43 percent of the national farm income. Export markets provide a significant source of income for western producers--in 1980 about 40 percent of the total U.S. agricultural exports. Western agriculture also generates employment in food processing, food transportation, and other industries that flow from agriculture. Western rural economies are highly dependent on agriculture and many small towns are primarily agricultural service centers.

The long-term future of western agriculture is uncertain. Elements that will affect its future include increased water restrictions on agriculture, and increased costs of water for agriculture, resource degradation, and increased competition of water from nonagricultural uses--e.g., urban development, recreation, transportation, and energy. If present trends continue, agriculture in the 17 western States will be increasingly threatened and adverse impacts could be felt nationally, particularly in total farm income, export sales, and western economies directly or indirectly dependent upon agriculture.

A number of policy options are presented in the OTA report to help ensure sustainable western agriculture. As mentioned in the submitted testimony, these include the establishment of a National Center for Water Resources Research to coordinate the nation's university research programs and a small specialized analytical unit to analyze and synthesize resource data for Congress. Other options include the following:

- o develop and promote technologies for dryland and rangeland agriculture that regenerate degraded lands and sustain long-term productivity to provide new economic opportunities where traditional irrigation is threatened.
- o tailor and adjust Federal programs to reflect the importance of the western mountain snowpack for arid/semiarid lands water production for western agriculture.
- o sustain the Federal commitment to water-quality programs including control of nonpoint agricultural pollution and public health research.
- o assist States in developing computerized water-resources data bases to improve capacity for local and regional water planning and management for agricultural and other uses.

6. Regarding western population growth:

In many ways, unmanaged population growth constitutes a major long-run threat to agricultural growth and development in the West. People increase demands not only on water supplies but also on space. Since cities grow more easily on level terrain, farmers and urban developers compete for the same valleys. Population increases promote commercial and

industrial sectors of the economy, which in turn attract more people in search of jobs. Much of the West is fully involved in this spiral, and local conflicts over land and water use are becoming commonplace. Moreover increased pressures on water supplies generated increased water reuse, thereby raising the likelihood of water quality deterioration unless improved water pollution control measures are implemented, particularly in nonpoint source pollution activities.

Traditionally, agriculture has been dominant in establishing and maintaining the particular flavor of western living and, to a large extent, has defined the economic, political, and cultural legacy of the region. As western populations expand in nonfarm sectors, greater demand is placed on land and water resources formerly used by farmers and ranchers. Decisions about who will get water may increasingly be affected by the "value" or "cost" of the water and by which competing users will be willing and able to pay. The character of the voting population may increasingly be interested in urban and suburban interests that are not necessarily compatible with agricultural interests unless the value of agriculture can be better communicated to these growing populations.

Finally, perceptions are changing about the value of water in various uses. Traditional water use and development relationships have been substantially altered in recent years by a broadening of interests. Environmental values, for example, have gradually gained a more prominent level among public priorities. Support at the local level has grown for retaining water resources in a natural state. Because of funding problems and these kinds of changing perceptions, many experts expect that the Federal role in building and operating new large-scale water projects (including irrigation projects) will decline sharply. This trend may affect irrigation agriculture, particularly regarding expansion to new areas or reclamation of existing areas that are suffering from severe salinity problems and require additional water supplies for flushing.

Enclosure 1

WITNESS QUESTIONS FOR BRUCE SMITH

1. YOUR TESTIMONY ADDRESSES THE IMPORTANCE OF RE-ESTABLISHING NATURALLY STABLE ECOSYSTEMS.

A. WHAT PERCENTAGE OF LAND IN THE WEST IS RIPARIAN LAND?

There are approximately 855,000 acres of riparian habitat on public lands in the Western States, excluding Alaska. This is approximately 0.4 percent of the total BLM-administered land in the West.

B. IF THIS IS SUCH A SMALL LAND AREA, WHY IS IT SO IMPORTANT TO SPEND TIME AND MONEY ON THESE RIPARIAN SYSTEMS?

Wildlife use riparian zones disproportionately more than any other type of habitat. For example, of the 363 terrestrial species known to occur in the Great Basin of southeastern Oregon, 288 are either directly dependent on riparian zones or utilize them more than other habitats. Many aquatic and semi-aquatic species are found nowhere else. Vertebrates that either reproduce in water or feed in water are totally dependent on riparian and adjacent aquatic zones. The water in these zones is the habitat for aquatic life forms--from invertebrates to fish, reptiles, amphibians, birds, and mammals. In short, riparian zones are the most critical wildlife habitats in managed rangelands.

All riparian zones within managed rangelands of the Western United States have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass--plant and animal--than the remainder of the area; and (4) they are a critical source of diversity within rangelands.

Riparian zones in managed rangelands are also disproportionately important for other uses. Stream margins frequently contain highly productive forage sites. Cattle use the vegetation in riparian areas more heavily than that in other areas, because they concentrate in riparian areas. The relatively gentle topography, particularly in areas of otherwise rugged topography, makes riparian zones attractive for road locations. Streams and rivers and their banks are also handy sources of rock and gravel for building roads. Mining has had and does have direct and indirect impacts on riparian zones. Recreationists concentrate their use in such areas. In addition, scenic values are often high. The water in such zones, particularly on dry western ranges, is critical to man's use, and rangelands are second only to cultivated lands as a source of water-quality problems. As a result, riparian zones are often the most critical zones for multiple-use planning.

C. WHAT PROPORTION OF TIME AND MONEY IS THE BLM DIRECTING TOWARD RIPARIAN MANAGEMENT?

Management of riparian areas is an important work item in the Bureau of Land Management's (BLM) Fiscal Year (FY) 1984 annual work plan. In carrying out the mandates of Executive Order 11988 (Floodplain Management), the BLM has issued instructions to the field such as Instruction Memorandum No. 83-602 (copy attached), for consideration of riparian/wetland areas in land disposal actions.

Riparian areas scheduled for management and funds directed by BLM's Division of Wildlife in FY '84 include the following:

Treatment	Acres	Cost
Monitoring, Inventory, Habitat Development, Maintenance	14,586	$353,751

Total funds directed in FY '84 toward riparian area management by BLM's Division of Wildlife amount to approximately 3 percent of the total wildlife budget. These figures gain greater significance when considering the fact that of the 855,000 acres of riparian habitat on public lands, approximately 500,000 acres are in need of management.

Riparian area management is also carefully considered in the management of the public lands for livestock grazing and watershed protection. A grazing or watershed management plan encompassing areas with riparian habitat typically contains specific objectives for that habitat along with management techniques designed to either accomplish total protection, or enhancement through such management techniques as manipulation of livestock grazing (seasonal use, rotational grazing system, or controlled level of utilization by livestock). The grazing management plan may also propose fencing of riparian areas to accomplish these objectives. The costs associated with meeting riparian area management objectives are included in the overall costs for management of the vegetative and soil resources within the plan area.

D. WHAT PROPORTION OF RIPARIAN AREAS WOULD BENEFIT FROM THE TYPES OF TECHNOLOGY WITH WHICH YOU ARE WORKING?

The application of livestock grazing treatments and beaver-associated erosion control processes as a riparian area improvement technique is relatively new in Wyoming. The results, thus far, have been very encouraging, however. We are confident that application of this technology to broader areas of the West where the combination of soil, vegetation potential and climatic conditions are favorable will help in the establishment of naturally stable riparian ecosystems. We have not calculated the proportion of the 855,000 acres of riparian habitat that would benefit from application of this technology.

2. WE'VE READ WITH INTEREST ABOUT YOUR WORK WITH THE BEAVERS AND THEIR DAMS.

A. WHAT KINDS OF PROBLEMS HAVE YOU ENCOUNTERED WITH THE INTRODUCTION OF BEAVERS INTO HIGHLY ERODIBLE AREAS?

Several problems have been encountered in refining our techniques and applying them to highly erodible soil areas. First, because of the lack of a food and dam construction material source for the beaver, woody vegetation must be transported in to sustain the beaver. We have also had to "reinforce" the dams to prevent their washing out. Rapid vegetative stabilization is essential once the ponds fill with sediment (sometimes within 30-60 days after spring runoff). Vegetative stabilization is essential in helping to prevent the stream from cutting around the end of the dam. The rechanneling and sedimentation problem has been particularly troublesome in the highly erodible watersheds.

Acts of vandalism including harassment, shooting, and dam destruction have also been problems.

B. DO YOU FORESEE UNEXPECTED CONSEQUENCES INVOLVED WITH THE BEAVER DAMS, SUCH AS FLOODING OF LAND THAT YOU DO NOT WANT FLOODED?

Flooding can be expected especially in areas of heavy spring runoff and where dams have filled with sediment. We have utilized several techniques to alleviate flooding problems such as "beaver fences" around culvert openings, "beaver pipes" through the dams to control pond water levels and net wire collars to protect desired trees. Where appropriate measures are applied, flooding problems can be kept to a minimum.

C. WHAT HAVE BEEN THE MOST SUCCESSFUL COMPONENTS OF THE BEAVER PROJECT?

Some of the most successful components are:

(1) The rapid (within 6 weeks) establishment of numerous small check dams which serve as hydrologic "checkpoints," which step down the stream's energy, thereby slowing runoff, reducing its sediment-carrying capacity, reducing potential for stream bank erosion.

(2) The relatively low construction and maintenence costs associated with achieving the change in stream hydrology.

(3) A raised water table, leading to the rapid establishment or recovery of riparian vegetation.

(4) Stabilization of a self-supporting recovery system within 2 to 4 years.

3. YOU STATE THAT CHANNEL EROSION IS RESPONSIBLE FOR WATER MANAGEMENT LOSSES SUCH AS REDUCED WATER QUALITY AND RESERVOIR STORAGE DUE TO INCREASED SEDIMENT.

A. IS IT POSSIBLE FOR YOU OR OTHERS IN YOUR AGENCY TO ACTUALLY MEASURE THE RATE OF SEDIMENT LOSS ATTRIBUTED TO CHANNEL EROSION COMPARED WITH UPLAND EROSION.

Our soil and water program is in the process of adapting standard quantitative procedures for quantifying soil erosion for use in rangelands in cooperation with the Agriculture Research Service, Soil Conservation Service, and Forest Service. This will allow quantification of upland erosion. The amount of channel erosion can only be estimated by: direct field observations and measurements; or indirectly by measurement of key total stream sediment load and subtraction of the estimated upland soil erosion entering the stream system. Both methods will produce a rough estimate of the relative contribution of both sources. However, both are costly and time-consuming or require data which are not commonly available.

B. HOW MUCH EROSION IS ATTRIBUTED TO RIPARIAN AREAS VERSUS UPLAND AREAS?

We do not have data on the contribution of channel erosion occurring in riparian areas on public lands.

As I stated in my testimony, in areas of erosive soils where the vegetative system has been altered (for example, removed by livestock overuse), severe erosion can and does occur. As the riparian ecosystem is restored, the streambank erosion potential is reduced. However, the upland areas may continue to produce sediment regardless of riparian habitat re-establishment.

4. ON PAGES 3 AND 4 OF YOUR TESTIMONY, YOU CITE EXAMPLES OF "CONTEMPORARY SOLUTIONS" TO RIPARIAN HABITAT AND ACCELERATED EROSION PROBLEMS.

A. COULD YOU DEFINE WHAT YOU MEAN BY "CONTEMPORARY SOLUTIONS"?

By "contemporary solutions," we are referring to state-of-the-art land management actions which are directed at solving a particular problem.

Examples of how we are developing "contemporary solutions" are:

(1) We are monitoring twenty riparian areas in BLM's Rock Springs District to determine riparian site potential on an allotment-specific basis. These areas will be control areas for determining the success of specific grazing allotments, and allow for the analysis of special management techniques (burning, planting, spraying) prior to treatment of large areas.

(2) We are proposing to establish "Special Riparian Management Units" for the purpose of developing and applying state-of-the-art riparian improvement techniques for optimum habitat development as mitigation for riparian habitat losses. These areas could serve as "showcase management" projects for public education.

(3) We have developed riparian sensitive range management grazing plans sensitive to riparian management, giving special emphasis to growth requirements of woody species such as willows.

(4) We are developing new biological management techniques for cost-effective land reclamation--such as the use of beaver to improve stream stability and riparian habitats.

B. COULD YOU GIVE EXAMPLES OF TRADITIONAL SOLUTIONS TO THESE PROBLEMS?

Examples of traditional solutions to these problems would include construction of concrete or earthen check dams, contour furrowing and reseeding, mechanical vegetative conversions, and replanting efforts.

5. YOU STATE THAT THE BLM WORKS IN CLOSE COOPERATION WITH OTHER FEDERAL AND STATE AGENCIES IN ITS LAND-USE MANAGEMENT AND PLANNING IN ORDER TO PROVIDE FOR ENVIRONMENTALLY COMPATIBLE OIL AND GAS DEVELOPMENT OF THE WYOMING OVERTHRUST BELT.

A. COULD YOU EXPLAIN IN MORE DETAIL SOME OF YOUR COOPERATIVE EFFORTS WITH THESE AGENCIES?

The BLM participates in:

(1) The Overthrust Industrial Association's cooperative program, which is designed to work with citizen's groups, the Game and Fish Department, Federal agencies and universities to help alleviate environmental problems in oil and gas development.

(2) Information transfer and technical assistance to the Wyoming Office of Industrial Siting relative to their concerns on accelerated erosion and ecosystem impacts.

(3) Technical presentations to oil and gas industry workshops to heighten their awareness and understanding of developmental impacts on aquatic ecosystems.

(4) The BLM, Forest Service, and Wyoming Game and Fish Department coordination meetings with field trips, and input to environmental impact statements for more effective conflict resolution or mitigation.

(5) Special Scientific Studies permitted by the Wyoming Game and Fish Department, such as the beaver/habitat rehabilitation, Bone Draw, and other cooperative management efforts.

IN REPLY REFER TO:

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
WASHINGTON, D.C. 20240

6840 (240)
7200 (222)
(320)

June 6, 1983

Instruction Memorandum No. 83-602
Expires 9/30/84

To: All State Directors

From: Director

Subject: Wetland, Floodplain, and Endangered Species Consideration in Planning for Land Disposal Actions

Introduction

In order to meet the current Federal initiative to dispose of excess lands (Asset Management), it is important that we also meet our responsibiliti[illegible] protecting federally listed threatened and endangered species, [illegible]dplains, and riparian areas. Compliance with the Endangered [illegible] (ESA) and the Executive Orders (EO's) dealing with floodpl[illegible]agement and wetland protection has the potential for significantly increasing our workload.

To assist you in planning efforts for the land disposal initiative, we are restating some of the requirements of the ESA, EO 11988, dealing with floodplain management, and EO 11990, dealing with protection of wetlands.

Endangered Species Act of 1973, as Amended

The purposes of the ESA are to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species."

The Act provides also that it is "the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

In both the purposes and policy statements, the Federal agencies are charged with conserving T/E species. "Conserve", as used in the Act, means "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary."

These statements from the ESA make it clear that our actions must be directed toward recovery, not merely preventing jeopardy to the continued existence of listed species. In this light, we should protect any lands that are important to these species. Therefore, it is Bureau policy to retain in Federal ownership all habitat currently used by federally listed threatened species and endangered species, the disposal of which would adversely affect the likelihood of survival or recovery of the species. It is also policy to retain all land areas historically used by threatened species or endangered species if such land is still suitable habitat and is needed for recovery of the species.

Some T/E species habitat involved in a disposal action may be only incidentally used by migratory species such as the peregrine falcon or bald eagle. In those cases, the Fish and Wildlife Service (FWS) should be consulted informally to determine whether disposal would adversely affect the involved species. If no adverse effects are expected to occur, the area could continue to be considered for disposal.

The requirements for compliance with Section 7 of the ESA apply to all land disposal actions. If in the planning process a manager determines that a proposed land disposal will affect a federally listed threatened or endangered species, formal consultation must be initiated with the FWS before the lands can be offered. This consultation will be required regardless of whether the impact is positive or negative.

Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands)

These Executive Orders have two major objectives:

1. To avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy or modification of floodplains or destruction or modification of wetlands; and

2. To avoid direct or indirect support of floodplain or wetland development whenever there is a practical alternative.

To meet these objectives, the EO's direct each Federal agency, in carrying out its responsibilities for disposing of Federal lands, to provide leadership and take actions to reduce the risk of flood loss or loss or degradation of wetlands, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains and wetlands. The EO's further state that when property in floodplains or wetlands is proposed for disposal to non-Federal public or private parties, the Federal agency shall take the following actions: (1) reference in the conveyance those uses that are restricted under identified Federal, State,or local floodplain and wetland regulations; and (2) attach other appropriate restrictions to the uses of properties by purchaser and any successors; or (3) withhold such properties from conveyance.

A recent field Solicitor's Opinion dated April 7, 1983 (see Enclosure 1) expands on these requirements with the following statement: The BLM can "authorize the sale of wetlands when:

"1. The tract of public wetlands is either so small or remote that it is uneconomical to manage.

"2. The tract of public wetlands is not suitable for management by another Federal agency.

"3. The patent contains restrictions of uses as prohibited by identified Federal, State, or local wetlands regulations.

"4. The patent contains restrictions and conditions that ensure the patentee can maintain, restore, and protect the wetlands on a continuous basis.

"In order to meet these requirements, the Bureau must engage in careful and extensive land use planning. If any of these four requirements cannot be satisfied with respect to a particular wetlands tract, the tract must be retained in Federal ownership and administered by the Bureau in the manner set forth in BLM Manual, Part 6740."

Therefore, it is our policy to retain in Federal ownership all wetlands, riparian, and floodplain areas if their disposal would violate the intent of EO's 11988 or 11990.

Application of Wetland, Floodplain, and Endangered Species Guidance

Determination of whether or not a particular piece of land qualifies for disposal should be made at the earliest possible time in the planning process. Guidance for planning land disposal actions is described in Washington Office Instruction Memorandum No. 83-373 (see Enclosure 2). Where land-use planning for land disposal is already complete, the above guidance should be reexamined and considered prior to clearance for land disposal.

The case file for each disposal action must contain statements that threatened or endangered species, wetlands, riparian areas, and floodplains have been considered in the decision. A suggested format is as follows:

> The information available indicates that this disposal will not adversely affect threatened species or endangered species or their habitat, or reduce the likelihood of their recovery, nor will this sale lead to the loss, destruction, or degradation of wetlands or riparian areas, or lead to the occupancy, modification, or loss of the natural and beneficial functions of floodplains.

This statement may be incorporated into the Record of Decision associated with the environmental analysis prepared during land-use planning. Any questions concerning these policy statements can be communicated to the Director (200) or Director (310).

James M Parker

Associate Director

3 Enclosures
Encl. 1 - Memorandum from Field Solicitor, Santa Fe, "Sale of Wetlands" (3 pp)
Encl. 2 - Instruction Memorandum No. 83-373, "Planning for Land Disposal Actions" (3 pp)
Encl. 3 - National Wetlands Inventory Maps Are Available From The Fish and Wildlife Service's Regional Wetland Coordinators (1 p)

Enclosure 2

WITNESS QUESTIONS FOR DAVID TIDWELL

CURRENT POLICY IN WATER MANAGEMENT

1. IS THE CURRENT NATIONAL POLICY IN WATER MANAGEMENT ADEQUATE TO MEET THE NEEDS OF AGRICULTURE BOTH FOR NOW AND FOR THE LONG-TERM FUTURE? PLEASE EXPLAIN.

Yes. The Department of the Interior's current policy is that the States have the primary authority and responsibility for the allocation and management of water resources except as otherwise specified by Congress. It is also Departmental policy that the BLM comply with applicable State law to appropriate water and cooperate with State Governments to protect all water uses identified for public land management purposes.

2. IS THE BUREAU OF LAND MANAGEMENT ADDRESSING THE ISSUES OF GROUNDWATER QUALITY AND QUANTITY FOR AGRICULTURE USE ON PUBLIC LANDS?

ARE ANY OTHER FEDERAL AGENCIES CURRENTLY ADDRESSING THESE PROBLEMS ON A LONG-TERM BASIS?

Yes. The U.S. Geological Survey collects and coordinates water data activities among Federal agencies. The Bureau of Land Management, Soil Conservation Service, Corps of Engineers, and Environmental Protection Agency also deal with groundwater issues.

3. WHAT SHOULD THE FEDERAL GOVERNMENT BE DOING IN GENERAL TO RESOLVE THE WATER ISSUES ON A LONG-RANGE BASIS? PLEASE EXPLAIN.

The Federal Government already has the means and is strongly involved in the resolution of water resources issues on a long-term basis. The major Federal water resources agencies--the Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service, and the Environmental Protection Agency in conjunction with other Federal agencies, such as the Fish and Wildlife Service, the Geological Survey, the Forest Service, and BLM--have continuing responsibilities in planning, construction, and management of the resource to meet near-term and future problems and issues. These agencies, together with the States and interstate agencies, and public and private entities constitute an effective and organized intelligence force with regard to the water resources situation. The information and data generated by this system of agencies, and the planning and implementation of programs and projects represent a responsive process of issue resolution which may be accelerated or intensified according to circumstances. This agency system interacts with the political process of ideas, choices, elections, and legislative branch oversight, statutory enactment, and appropriations to provide direction and decision. Under this Administration, the entire process has been enhanced by the elevation of water resources programs to the cabinet level.

That is, the Cabinet Council on Natural Resources and the Environment has direct purview of the water issues which means the issues have the attention of the President. Furthermore, there is a Working Group on Water, responsible to this Cabinet Council, which includes assistant secretaries from Army, Agriculture, and Interior and the Deputy Administrator of the EPA. This working group provides for coordination of the major water programs and issues on a timely and frequent basis.

WITNESS QUESTIONS FOR DR. ROBERT LOCY

1. *Your testimony discusses briefly some of the work you and your colleagues are engaged in at Native Plants, Inc. (NPI).*

   A. How much time and resources are you devoting to developing plants that are salt tolerant, or able to tolerate lower quality water used for irrigation?

   -- Plants that are tolerant to dry weather conditions?

   -- Native plant species that may be both salt-tolerant and arid-weather tolerant?

1. A. My estimate would be that about 1/4 to 1/3 of our companies research time and resources are devoted to these areas.

   B. From your experiences, can you tell if it is more cost-effective and efficient to <u>improve</u> existing crop species or to <u>develop</u> new crop species that could be used in the arid west for agricultural purposes?

   B. The development of a new crop generally means that a new commodity is being produced. Such a new crop will be successful and useful only if a market for the consumption of the new commodity exists or can be created. Uncertainty about the acceptability of a new crop is the best argument for working on improving existing crops.

2. *On Page 1 of your testimony, you state that gene cloning which is used to pass on desirable traits in plants is a very rapidly advancing technology.*

A. Can you project the impact cloning will have on sustainable agriculture in the arid west in the future?

2 A. This is difficult to do, and I'm sure there are as many opinions about this as there are experts. I would say that in the next 5 years these technologies will have little impact. In the next 10 years the impact will be apparent, and 10 years from now the impact could be great. Two reasons suggest such a time table. First, the nature of crop plant improvement is such that it takes a minimum of 5 years to produce and test a new crop genotype. Second, we do not know enough basic biology and physiology of factors that would contribute to sustainable agriculture in the arid west.

B. To what extent is cloning being used today to develop crops with desirable traits?

B. The technology for using gene cloning to develop new genotypes of crop plants is currently being developed by both public and private sector institutions. The effort and resources being used for the development of these technologies probably equals the effort placed on conventional plant breeding. However, the technology has not yet developed to the point where it is currently being used to directly develop new crop genotypes.

RESEARCH

3. *On page 1 of your testimony, you state that there is a strong need for understanding better basic plant physiology in order to advance the use of biotechnology.*

A. Can you identify basic research needs in the field of biotechnology?

3 A. All areas of basic plant science research have traditionally been underfunded. In order to expedite the application of biotechnology to plants, the slowest developing area seems to be the development of capabilities to regenerate whole plants from cultured plant cells and protoplasts, thus, basic research in plant morphogenesis from culture is needed. In areas relating to the development of biotechnology for arid and semi arid lands, the areas would be plant water use efficiency, drought stress tolerance and salt stress tolerance.

B. Can you possibly identify how much Federal effort is being directed to those basic research needs?

B. Research on these areas is funded by several federal agencies including NSF, USDA, and DOE. The exact level of funding in each of these areas is difficult to determine since there are no specific programs devoted to these topics, and projects are funded on an individual basis.

C. Are these research needs being addressed at NPI?

C. Yes, but our resources are limited by comparison to the effort needed.

FEDERAL GOVERNMENT VS. PRIVATE SECTOR

4. *You state on page 2 of your testimony that "a substantial funding commitment to basic plant sciences which has traditionally been lacking is needed." You also allude to the fact that there are several small government programs for basic plant science.*

   A. *Is it possible for you to identify these government programs, and to the best of your ability, the research they are conducting.*

4. A. Probably the most visible program in the basic plant sciences is the USDA Competitive Grants Program. This program funds research in 4 basic plant science areas which include: photosynthesis, biological stresses, genetic mechanisms of crop improvement, and biological nitrogen fixation. Other programs which fund basic plant science research can be found in the NSF and DOE. These would include the Metabolic Biology, Developmental Biology, and Genetic Biology programs at NSF, which fund basic animal, microbial, and plant research, and the Division of Biological Programs at DOE. There is also a program called the Israel-U.S. Binational Agricultural Research and Development Program which funds basic plant science research. Each of these programs is quite broad based and it would be difficult to identify specific research funding in these areas. In addition to these governmental funding programs, the USDA and DOE are involved in basic plant science research funded in house. Again the scope and details of those programs are not easily summarized here.

The point that I would make is that based on statistics which I have seen for Fiscal year 1981, the government spent around $76 million on basic plant science research compared with $15 billion on military research, about $4 billion on health related research, and $5 billion on energy research. I understand a forth coming OTA report on all areas of Biotechnology will present more complete statistics than I have given here. My point is that by comparison to many other research areas, basic plant sciences are dramaticly underfunded.

B. Do you believe that the 30 private biotechnology firms in the United States were developed in part because of a lack of Federal commitment and funds to this rapidly developing field?

C. Is there a role for the Federal Government in supporting technologies that are changing so rapidly?

4. B and C. These points were covered during my testimony, but I would again stress that the role of the federal government should be to aid in the development of the basic plant sciences.

5. As a private firm, what ability do you have to introduce some of the crop species you are developing into the commercial market?

A. Do you have agreements with any of the agricultural experimental stations or land-grant universities to use the crops you are developing?

(If not,)

B. Do you foresee the need for this, or would there be an intermediate step between your firm and the agricultural experimental stations?

5. A and B. These points were covered during my testimony.

[From the New York Times, Aug. 15, 1983]

U.S. Puts Beavers To Work Restoring Creeks

(By William E. Schmidt)

Rock Springs, Wyo., August 11.—Like most ranchers, the people up Currant Creek would just as soon shoot a beaver as look at it. For years, the animals had dammed the stream, flooded their hay meadows and plugged their drainage culverts with mud and sticks.

Then, two years ago, the Federal Government started trapping the beavers and setting them loose at a site below the ranches where the banks of the creek had been badly eroded.

The beavers, using timber left at streamside by Government biologists, built a series of dams that slowed the swift creek, checking the erosion that had turned the water brown with mud and had killed much of the vegetation.

The creek began to back up in shallow ponds that spilled over the banks of the old channel. Willows and grass, good forage for the cattle that use the creek banks for winter range, started to sprout amid the brittle clots of prickly greasewood. Trout returned to the creek, and songbirds nested again along the marshy banks.

Many here have changed their minds about the beaver.

"It's just a matter of letting nature take its own course," said Bruce Smith, a wildlife biologist with the Federal Bureau of Land Management and one of the men who devised the idea of using the beavers to help restore the stream. "It's a lot cheaper and makes a lot more sense than trying to artificially control the environment."

For decades, here and elsewhere, cattle and sheep stripped vegetation from the stream banks each winter. High water the next spring would tear away at the banks, weakened by the absence of roots and other vegetation that help hold the soil together. In some places, the creeks have eaten into their banks by more than 50 feet since the early part of the century.

Federal and state engineers and private landowners in the West have spent millions of dollars trying to stop erosion along the narrow creeks that weave through the arid sagebrush hills of the region. They have built dams of concrete and dams of wire mesh filled with rocks. They have lined riverbanks with boulders.

But as far as anyone knows, Mr. Smith and his colleagues, Larry Apple and Dick McCuistion, were the first to leave the dam-building to the beavers.

The beaver project on Currant Creek is one of two being studied by the Federal land agency here in the rugged, sagebrush hills southwest of Rock Springs. The second, on nearby Sage Creek, has had similar results. Within three summers along the half-mile stretches of creek, the beavers have not only reversed the worst of the erosion but have also raised the level of the creek bed by several feet in some places, as silt carried by the current is deposited behind the dams.

In all, Mr. Smith estimates that the Federal land agency has invested less than $3,000 in materials and equipment in running the project since he framed it six years ago. By contrast, a single dam along a small stream can cost anywhere from $3,000 to $100,000, depending on size and materials.

BEAVERS GOT SOME HELP

The beavers did need some help in getting started, since erosion along the two streams had denuded them of the kinds of heavier vegetation the animals normally use to build dams.

So Mr. Smith and Mr. Apple trucked in aspen logs thinned from a Federal forest area 15 miles away and stacked them along the stream banks. In addition, along parts of Sage Creek, they strung old truck tires from bank to bank, as a foundation for the dams.

Eight beavers were trapped and released in the streams, and within months they had begun to slap sticks and mud atop the logs and tires, slowing the current and forcing it to spread out.

As it does so, the water table along the streams goes up, helping replenish the grasses and willows. On Currant Creek, an electric fence was also installed around the site to keep cattle from the creek bed so the vegetation could replenish itself.

RANCHERS AND DEER TO BENEFIT

Ultimately, the increased vegetation along the streams will most directly benefit cattle ranchers who lease the federally owned lands near Sage and Currant Creeks

to use as winter range for their herds. It will also provide forage for deer and antelope, which roam wild over the desolate range, and critical nesting areas for birds.

The project here has attracted attention throughout the Western states, where perennial, spring-fed streams like Currant and Sage Creeks provide a vital source of water in an otherwise dry and hard land and are vital to both livestock and wildlife.

In Utah, state game officials are planning to introduce beaver to help check erosion on a creek northeast of Salt Lake City. At the University of Wyoming, range scientists are studying the broader use of beavers as a tool to help check erosion.

MUCH HABITAT HAS BEEN LOST

According to Mr. Smith, erosion and a lowered water table on streams in southwest Wyoming has already destroyed more than 83 percent of the critical riparian meadow habitat that once flourished along the creek banks.

Mr. Smith said the beaver activity is also likely to benefit downstream users as sediment is deposited behind the dams rather than being carried down. On a large enough scale, he says, beaver dams along many of the upper tributary streams of Colorado River could have a positive effect on water conservation, since sediment washed into downstream reservoirs reduces storage capacities.

Though beavers still flourish throughout the arid West, their numbers are small compared with the 18th century, when their abundance urged armies of European trappers into the Rocky Mountain region to slaughter them for their rich pelts.

BH Smith Ref

PROCEEDINGS
of the
15th Annual Meeting
Colorado-Wyoming Chapter
American Fisheries Society
February 27-28, 1980
Fort Collins, Colorado

NOT ALL BEAVER ARE BAD; OR, AN ECOSYSTEM APPROACH TO STREAM HABITAT MANAGEMENT, WITH POSSIBLE SOFTWARE APPLICATIONS

Bruce H. Smith, U.S.D.I., Bureau of Land Management, P.O. Box 1869, Rock Springs, Wyoming 82901.

Abstract: Pilot studies in the Rock Springs District have indicated the establishment of stream habitat improvements can be achieved through a "software" approach of providing environmental limiting factors for beaver, i.e., necessary material and food supplies. When applied within a multiple-use management framework, this approach could prove to be highly compatible with other programs (e.g., aspen thinning to stimulate big game browse regeneration).

In addition, when compared to physical instream improvements, the approach could be quite cost effective in light of present material, installation, and maintenance costs.

Introduction

The Rock Springs District stream inventory of 1975-1977 evaluated 1,143 miles of stream habitat on public lands, in order to develop baseline information for the Bureau's multiple use programs. One of the major findings of this inventory was the reduced habitat quality and carrying capacity of many mid-sized streams with flows of 1-10 cfs. Insofar that these reductions are due in large degree to excessive bank erosion, stream bottom sedimentation and reduced quality of resident pool habitat, independent recommendations have been proposed (Behnke, 1976) to mitigate losses in game fish carrying capacity through the construction of reservoirs. While this is a potentially viable mitigating measure, there are limitations for implementation within existing program funding levels, state's water rights conflicts, etc. By taking a "software" approach to the problem, however, natural systems are often found to exhibit extensive on stream water storage sites in the form of beaver ponds, which can significantly increase the productivity and carrying capacity of a free flowing stream (P-1). During the stream survey, on stream beaver ponds were evaluated in relation to their fisheries habitat significance. A Districtwide set of average conditions was subsequently developed (Table 1), from which individual streams or drainages could be compared.

Table 1

On Stream Beaver Pond Habitat-District Stream Survey 1975-1977

No. Ponds Sampled	Average No./Mi.	Average Size Ft^2 - Acres	Av. Max. Depth	Fish Blocks
1,509	1.3	1,408 0.03	2.0 ft.	48%

Active	Inactive	Silted	Not Silted	Fresh Water	Stagnant
50%	50%	89%	11%	91%	9%

Through analysis of the entire stream survey, it became apparent that stream habitat quality was often directly related to the condition of associated beaver complexes and their riparian zones.

Methods

Recognizing relationships between the total stream community and particularly, requirements for improved management of beaver related habitat, cooperative interagency (BLM and Wyoming Game and Fish) habitat management plans (for the Thomas Fork drainage and the East Front of the Wyoming Range) have identified objectives for the improvement of beaver habitat areas to enhance the survival of both the Utah cutthroat (S.c. Utah) and the Colorado River cutthroat trout (S.c. pleuriticus).

Call (1966) found that aspen supported beaver habitat in southwestern Wyoming approximated a thirty year boom and bust cycle (P-2). Typically, beaver move into a drainage and utilize aspen 200 to 300 feet from the stream (depending on slope). With the ultimate elimination of their food and material supply, subsequent sedimentation of the ponds and a transition into a marsh meadow habitat, beaver moved out of the area (P-3). During their absence, the aspen regenerate themselves and eventually, beaver move back into the drainage and once again begin developing on stream pond habitat. Rutherford (1964) identified numerous variables or environmental factors between different types of beaver populations and the niches which they occupy. These include the differentiation between river bottom, plains, or mountain beaver populations which are supported by cottonwood, willow, or aspen/willow plant communities, respectively. In addition, physical factors such as soil type, stream gradient, geological landforms and location within the drainage significantly influenced the success or failure of beaver establishment within a given reach of stream.

In the analysis of our stream inventory however, we found that it was difficult to apply any given cycle or standard set of conditions to define stream habitat related beaver ecology and riparian succession. Each stream was unique and existent habitat conditions were part of an ongoing dynamic interplay of all affecting forces, both physical and biological. As an example, it appears that many streams with aspen supported beaver complexes are not cycling at all; or may possibly be cycling in the neighborhood of 75 to 150 years (P-4). The gradual invasion of spruce/fir communities into former (or present) aspen occupied riparian zones leads to a climax situation, typical of a montane meadow type stream

(P-5). As another example, where beaver habitat is primarily supported by willows, the dams constructed are typically small, short lived, have trout habitat value for only two or three years, and may be cycling as rapidly as every five years (P-6, 7, 8 shows the same willow supported beaver pond series in 1974, 1977, and 1979, respectively). It appears that in areas with well established willow riparian zones (P-9), beaver activity may actually stimulate willow growth and can occur on a long term basis. While individual dams or groups of willows may phase in and out of the system, the influence of beaver activity on the overall stream can probably continue indefinitely.

In those riparian areas with both active beaver populations and intensive livestock grazing (P-10), it has been found that continued use of riparian vegetation without rest treatments (P-11) leads to a downward trend in not only stream habitat, but most resource values as well, livestock grazing included (Smith 1978). The loss of food and material supplies required to support the stabilizing influence of beaver activity, leads to progressive channel downcutting (P-12, 13, 14, 15), a lowered riparian water table, reduced bank storage and meadow carrying capacity, accelerated erosion, decreased watershed stability, plus a host of lost opportunities tied to ramifications of these basic impacts. In reaches of streams flowing through the cold desert biome, the loss of this stabilizing influence is even more dramatic (P-16, 17, 18). The quality of stream habitat for game fisheries in these situations is not merely reduced, but is often completely lost altogether. This degradation process continues until the channel approaches some level of hydrologic equilibrium and willows begin to re-establish (P-19), providing the basis for a regeneration of beaver influence on stream habitat (P-20).

Numerous differences between the conditions of beaver habitat (P-21) have been found to vary not only between drainages or individual streams, but also within separate reaches of the same stream. On a given stream, originating in a montane area and flowing out onto the cold desert, it is often possible to observe at least four distinct types of stream habitat associated with beaver activity. Typically, the stream starts out in a coniferous forest flowing through a meadow where signs of old beaver activity (dams, terraces, etc.) are still evident. The next reach exhibits remnant aspen stands, cut back from the stream and presently being invaded by conifers. On south facing slopes, less favorable for coniferous invasion, remnant aspen stands appear to be determinate (Gullion 1979) in nature and in a decadent or declining condition: Stream bottom habitat in this zone is primarily influenced by the existence of large, old, aspen based dams. Dams which are presently silting in, forming a wet meadow riparian zone and are providing the basis for extensive willow growth which provides materials for the maintenance of the old dams and construction of newer, smaller dams. The next zone is characterized by aspen stands cut back from the stream during recent dam building activity. The beaver dams are typically large, due to the utilization of aspen for materials; the ponds are generally young with good size and depth for trout habitat. The riparian zone is small or indistinct and willows are in the process of becoming established as the ponds begin to silt in (P-22). Having made the transition out onto the cold desert plains, many streams then become gully cut resulting in marginal game fish habitat. Only edifices of former riparian plant communities and the beaver complexes which they supported remain to illustrate the type of habitat which once existed.

Results

Historically, most discussions dealing with beaver habitat management have focused on negative aspects of the observed "boom and bust" cyclic nature of beaver activity. As an example, a typical reach of stream in which beaver activity had been developing since the early 1970's (P-23) showed signs of gradual habitat improvement and riparian utilization until 1978. By 1979, however (P-24), beaver populations increased to the point of almost complete utilization of riparian food and material supplies and a "bust" was imminent (P-25). At this point, the usual management requirement calls for an immediate reduction in population numbers. One of the most difficult ways to try and manage these natural cycles for extended productivity and maximum resource benefits, however, is through the utilization of equally volatile fur market demand and harvest activities (Hodgdon 1978). Both cycles seldom coincide and often, during periods of beaver abundance, we have found (P-26) instances where beaver attempt to establish themselves in sites which appear to be entirely unsuitable, to say the least. Out of necessity, they must often resort to utilization of greasewood, sagebrush, rabbit brush, or any available materials in an attempt to create (P-27) the habitat necessary for their survival. Quite often, under these same conditions (P-28) resource management agencies are faced with the problems of trying to improve degraded stream habitat for fisheries survival, watershed stabilization, riparian restoration, etc. In many instances, the applied method of improvement involves the installation of instream "hardware," such as gabion structures (P-29) or log drops (P-30). In addition to the initial capital investment required to install these types of structures, an ongoing and ever-increasing committment of funds is necessary for site maintenance, in order to keep the structures functional (P-31, 32).

Discussion

Every once in a while, during a lapse in the usual deadlines, brush fires, and crises which seem to characterize the general trend of business today, one has a few brief moments in which to sit back and think. It was during one of these rare moments that the thought occurred to me (P-33); "Here we are, with decadent or overmature aspen stands on slopes and ridge tops. Management programs are being developed to stimulate suckering and browse production in these stands through the use of controlled burns or cutting programs. On the other hand, adjacent drainage bottoms are in a declining trend and beaver are down to utilizing any material available in order to try and maintain their habitat and associated benefits to the watershed. Why not try to adopt a 'software' approach to solving some of our stream habitat problems and at the same time, obtain additional benefits from the aspen management programs?" Enter Operation SANTA CLAUS! (P-34).

Why wouldn't it be possible to reduce or eliminate capital investment costs and simply operate a program based on our usual time requirements for maintenance? Possibly, we could supply the limiting factor, a material and food supply, to these beaver and maybe, just maybe, they would perform the installation and maintenance activities for us. (!) (?)

Initial inquiries made to friends within the region about the rationality and feasibility of this idea most often resulted in a dubious or skeptical response, to put it mildly. However, after two years of trial and testing, the idea appears to be not only feasible, but may have valid applications in areas where other methods of stream improvement may be too costly or technically unfeasible (P-35).

It is possible to provide food and material supplies to beaver and have them improve stream habitat (P-36). These structures can, in fact, survive spring runoff, during which they provide for sediment storage, an elevated water table and bank recharge through over bank flows (P-37). With additional supplies of materials after spring runoff (P-38), beaver will not only maintain their present structures (P-39), but may even build new dams in the immediate area of supply (P-40, 41).

Summary

In order to work within an ecosystem framework towards solving resource management problems, it is desireable to look at the "big picture" and identify all affecting elements and limiting factors for the entire habitat site. This includes both physical and biological factors. In order to apply a "software" approach and work with beaver for stream habitat improvement (P-42), it is necessary to try and think like a beaver (P-43, 44). In light of all the limiting factors affecting beaver habitat establishment (P-45), (soils, stream flows, gradient, landform, food and material supplies, behavior, biology, etc.) I personally feel that beaver are basically opportunists (P-46). Opportunists with a large capacity for adaptation (P-47). The benefits which can be attained for fisheries habitat may be quite significant, especially when compared to the instream habitat conditions which would normally exist (P-48). In addition, secondary benefits may be realized through the establishment of an elevated water table, subsequent creation of new spring sources further downstream and the enhancement of the entire riparian zone (P-49). This method is by no means a solution to all of our problems. It is merely a method which has been shown to work. But in those areas where it will work (P-50), it once again restates the fact that, "It's pretty hard to beat a beaver!". For instream habitat improvement with multiple use benefits, there is a large degree of personal satisfaction in being able to work with a natural system, instead of against it or in spite of it.

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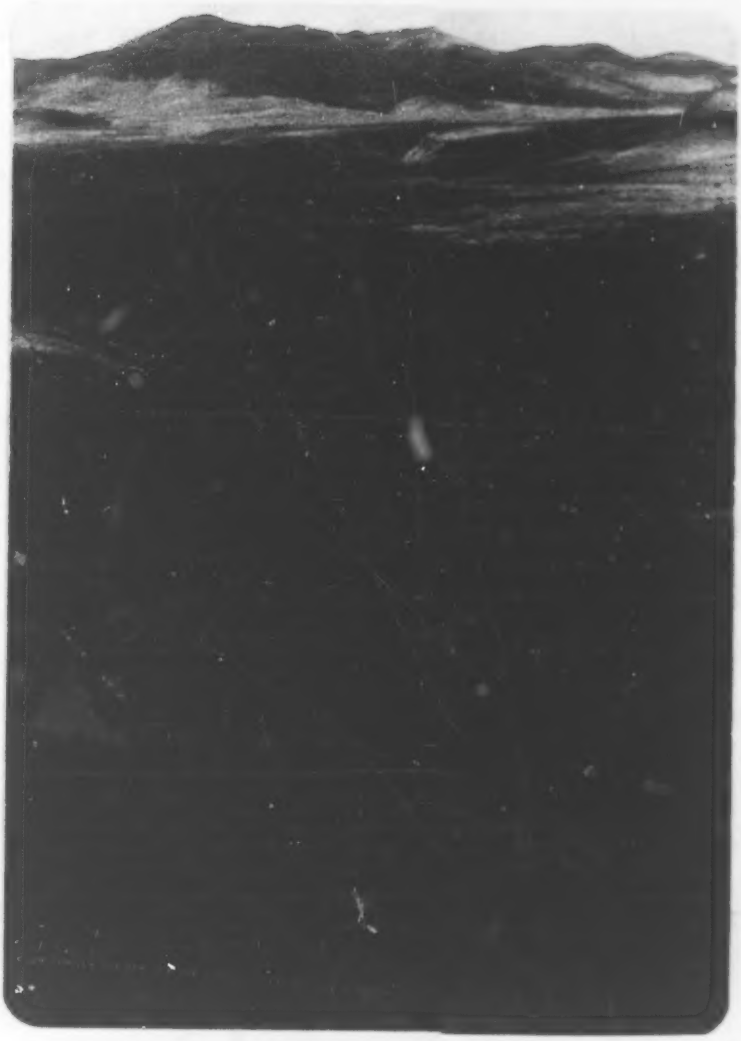
1. October 10, 1983—Tributary to Mary's River, Elko County, Nevada

Alternating Use Livestock Grazing System since 1973. Note willow growth to sod establishing on stream banks.

2. October 10, 1983—Tributary to Mary's River, Elko County, Nevada

Alternating Use Livestock Grazing System since 1973. Willow growth in stream channel has stabilized. Extremely heavy runoff in 1983. No apparent cutting.



3. October 10, 1983—Mary's River, Elko County, Nevada

No grazing system. No treatment.
Note unprotected gravel bars and limited streamside vegetation.

4. October 10, 1983

No livestock grazing system. No treatment.
No willows or streamside vegetation to slow flows or to prevent stream from enlarging its channel.